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CONTENTS

	Page
Human Rights and Duties	85
Archæology at Jebel Moya, Sudan. By Miss G. Caton Thompson, F.B.A.	87
School Science in America. By W. L. Sumner	88
A Chemical Technologist Looks Ahead. By Sir John Russell, O.B.E., F.R.S.	89
Electromagnetic Induction	89
The Harwell Cyclotron. By T. G. Pickavance, J. B. Adams and M. Snowden	90
Crazing of Cast Polymethyl Methacrylate. By E. W. Russell	91
Morphogenesis in Plants and Animals	96
Obituaries:	
Mr. H. H. Cousins. By Sir John Russell, O.B.E., F.R.S.	97
Mr. E. G. Baker. By Dr. W. B. Turrill	98
Mrs. Evershed	98
News and Views	99
Tuberculosis. By John Francis	102
Conference of Home Universities	104
Voyage of the Royal Research Ship *William Scoresby*	105
Agar from British Seaweeds. By Prof. F. E. Fritsch, F.R.S.	106
Letters to the Editors:	
Electron Microscope Studies of Normal and Malignant Tissues of High- and Low-Breast-Cancer Strains of Mice.—Prof. R. D. Passey, Dr. L. Dmochowski, Prof. W. T. Astbury, F.R.S., Dr. R. Reed and Dr. P. Johnson	107
Ground-Wave Propagation Across a Land/Sea Boundary.—P. C. Clemmow	107
Microscopic Space Charge in Electrolytes during Electrolysis.—Prof. William Schriever and Charles A. Reed	108
Supersonic Vibration Potentials (Debye Effect) in Colloidal Solutions.—Prof. A. J. Rutgers and J. Vidts	109
Double Orbit in the 30-MeV. Synchrotron.—J. D. Lawson	109
Phase-Shift Formula for Many-Body Collisions.—R. Kołodziejski	110
Utilization of Aspartic Acid and Asparagine by Yeast.—J. White and D. J. Munns	111
The Precipitin Reaction and Antibody Valence Studied with the Aid of Radioactive Isotopes.—Dr. T. E. Banks, Dr. G. E. Francis, W. Mulligan and Prof. A. Wormall	111
Significance of Tryptophane in Human Nicotinic Acid Metabolism.—W. I. M. Holman and D. J. de Lange	112
External Potassium and the Membrane Potential of Single Muscle Fibres.—Gilbert Ling and Prof. R. W. Gerard	113
Reversal of Glycogenetic to Glycogenolytic Action of Desoxycorticosterone in Rats.—Prof. F. Verzár and Dr. F. C. Wang	114
Production of Antisera in Rabbits using Calcium Alginate as an Antigen Depot.—D. Slavin	115
Effect of Calcium and Atropine on the Histamine- and Acetylcholine-induced Contraction of Unstriated Muscle.—E. Gy. Erdös and I. Csefkó	116
Demonstration of Glycogen and Lipids in the Cytoplasm of Human Neutrophilic Leucocytes.—O. Erānkō	116
Mutations Induced in *Drosophila* by Ingested Phosphorus-32.—A. J. Bateman and Dr. W. K. Sinclair	117
Dextran as a Diluent for Univalent Antibodies.—A. Richardson Jones	118
A Fungus in *Ectocarpus granulosus* C. Agardh near Plymouth.—Dr. A. A. Aleem	119
Changes in the Response of Silkworm Eggs to Rotational Force during Cleavage.—Dr. Alexander Wolsky	119
A Chimera in the Cultivated Strawberry.—Dr. W. S. Rogers	120
Soil and Vegetation in British Somaliland.—Dr. W. A. Macfadyen	121
A New Series of Analgesics.—D. W. Adamson and A. F. Green	122
Exchange in Cobalt Chelate Compounds.—B. West	122
X-Ray Irradiation of Polystyrene, Polythene and Paraffin Wax.—Dr. N. N. Winogradoff	123

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HUMAN RIGHTS AND DUTIES

IT is now more than a year since a Universal Declaration of Human Rights was adopted by the Assembly of the United Nations. This, however, was intended as only the first stage in the preparation of a Universal Bill of Human Rights which the United Nations has been inspired to undertake, largely in the belief that the rule of international law and the protection of fundamental human rights are essential both for the survival of civilization and the continued existence of the human race. A powerful impetus to the protection of the freedom of individual citizens from tyranny has been provided by war-crimes trials, but discussions are still proceeding on the second and third stages of the proposed Bill, namely, a Covenant on Human Rights and the measures of implementation. Meanwhile, the European Movement, from which has come the Council of Europe, has been giving attention to this question, and in particular to the need for a European convention. A draft European convention for the collective protection of individual rights and democratic liberties by member States of the Council of Europe, and for the establishment of a European court of human rights to ensure observance of the convention, with a draft statute for such a court, were submitted by the European Movement to the Committee of Ministers of the Council of Europe on July 12, 1949. This draft was accompanied by a recommendation that the whole question of the maintenance of human rights and liberties should be placed upon the agenda of the first session of the European Consultative Assembly at Strasbourg.

These documents are included in a useful reference book, "European Movement and the Council of Europe", published on behalf of the Movement*, to which Lord Russell contributes a chapter on Europe's cultural heritage. The reason for tardy progress is shown clearly in the symposium on human rights, edited by Unesco, which has in the meantime been published†. Whereas the idea of a court of human rights is derived largely from the belief that a code of international law is required which individuals and governments alike would be obliged to respect, the contributions to this symposium show unmistakably that there is one school of thought which is looking to the erosion of the law, rather than to its clarification and strengthening as the bulwark of individual liberties against tyranny in the way that Lord Justice Denning suggested in his recent lectures on freedom under the law.

This aspect is brought out most clearly in Prof. Sergius Hessen's contribution, though it can also be traced in those of Mr. John Lewis and Prof. Boris Tchechko. Prof. Hessen, in a long essay on "The Rights of Man in Liberalism, Socialism and Communism", recognizes that this doctrine of the withering away of State and law, however consistent and noble in its final aim, which, it will be noted, has affinity with the Pauline doctrine expounded in the

* European Movement and the Council of Europe. Pp. 203. (London: Hutchinson and Co., Ltd., 1949.) 10*s.* 6*d.* net.

† Human Rights: Comments and Interpretations. A Symposium edited by Unesco; with an Introduction by Jacques Maritain. Pp. 288. (London: Allan Wingate (Publishers), Ltd., 1949.) 15*s.* net.

Epistle to the Romans, is decidedly hostile to the very idea of the rights of man and of the liberties of the individual. Prof. Hessen, moreover, points out that the doctrine is unable to provide a programme for constructive work, and he proceeds to elaborate what is involved for science and technology on this very issue in the development of a new ideology and superstructure if we accept Communist premises.

There is no more thoughtful or stimulating essay in this symposium than that of Prof. Hessen, although to say that is not necessarily to accept his argument and views on the origin of the spiritual values in the Western tradition of civilization, their influence on the development of science and technology and the possibility of a new synthesis which incorporates that tradition of the rights of man. The concessions, in his view, are all to come from one side, and his essay, admirable as it is, seems to underline the conclusion of that of Prof. Kurt Riezler, that any bill of rights making those rights conditional on duties towards society or the State—however strong its emphasis on human dignity, freedom, God or whatever else—can be accepted by any kind of totalitarian leader. Such a leader would enforce the duties while disregarding the rights. Hence, Prof. Riezler urges, a bill of rights would be better restricted to rights, that is, to those rights which as minimum conditions, however insufficient, of human freedom, any State or society can respect and protect. These are the old civil liberties, and any addition, be it of economic rights or of duties, means in practice weakening the civil rights and their hold on the human mind. This view is in harmony with the draft convention submitted by the European Movement which would guarantee only those fundamental personal and political rights which it is practical to enforce in courts of law.

Nevertheless, this conclusion seems scarcely to face the point that it is on these two issues—the need to add economic to political rights, and the need to consider the duties as well as the rights of man—that most thinkers of to-day are conscious that the old eighteenth-century formulæ are inadequate. It may be true enough that we need, as General Smuts has put it, not only freedom but also discipline, and if we could be sure of the discipline, the practical difficulties in reconciling the Western and the Communist interpretations might disappear. In practice there is, however, no evidence of that; and the present symposium, while emphasizing the extent to which the addition of social and economic rights to the political rights so important in the eighteenth century has marked the modern conception of the rights of man, stresses, too, the need for remembering that rights cannot be divorced from duties.

The problem of reconciling political equality with political freedom is less simple than it appeared down to the time of J. S. Mill; and although we are here offered no solution, these essays should stimulate fresh and searching inquiry into the whole subject. They probe the claims advanced at present by both sides, and indicate a certain insincerity in the claim of either to offer a formula which makes the best of both worlds. In truth, it must be recognized that, as Prof. Quincy Wright points out, every formulation of a human right raises the issues of man versus the group, of group versus group, and of group versus the world; and on the answers we give, on which we are the final interpreter, depends whether or not society dissolves in anarchy, in war or in tyranny. In the definition of human rights, we must consider both the original nature of man and the contemporary standards of world civilization; and the human rights must be stated in terms which recognize their relation to the requirements of the State and to the authority of the world organisation. The implementation of each right must develop independently and gradually as the world community develops.

On the broad issue it may be said that the symposium only initiates the inquiry which Prof. E. H. Carr suggests should precede the drafting of an international declaration. No declaration of rights, he holds, would have any validity to-day if it did not include social and economic as well as political rights, nor would it have any serious meaning. Further, any declaration of rights and obligations of the individual in society should at the present stage be regarded as a declaration of intention, or as a standard to be achieved, rather than an internationally binding engagement. Benedetto Croce, too, suggests that Unesco's practical contribution should be a formal, public and international debate on the necessary principles underlying human dignity and civilization; but that the value of such a debate would largely turn on whether the present confusion in the use of terms could first be removed.

It is on agreement as to the meaning of the terms we use that the possibility of transcending ideological conflicts depends. Otherwise it is impossible to discuss such conflicts, as Prof. F. C. S. Northrop suggests, in the light of empirical and scientific evidence or to resolve them by means of scientific inquiry. But if Prof. Northrop is right in urging that the minimum foundation for a bill of rights is a political philosophy which is both a philosophy of all the world's cultures and a philosophy of science, there is little prospect that an adequate declaration will be formulated for decades to come.

It is not only in the field of philosophy that fresh thought is required. The symposium directs attention also to the failure of Western democracy to give sufficient thought to transferring the conception of independent public service to the conditions of mass democracy. That is the real issue which Lord Beveridge raised in his "Voluntary Action", and it is as important in the scientific as in the political field. Indeed, it may be said that the failure during the past two centuries to recognize that any definition of the rights of man is also a definition of the relation between the individual and society, and to think out in terms of rights and obligations the implications for both sides of the shift in emphasis, is a fundamental cause of the present problem of work incentives.

What is immediately required is, as has already been indicated, searching inquiry and constructive thought before legislation is drafted. Prof. Northrop at least recognizes by implication that one element in a bill of rights must be some guarantee of freedom for scientific and philosophical inquiry; and the

contributions to this symposium from Aldous Huxley, Prof. R. W. Gerard, Prof. J. M. Burgers and Prof. W. A. Noyes have the strongest claims on the interest of men of science. It is to be hoped, however, that they will not neglect to pursue also the lines of thought opened up by René Malen in a discussion of what is involved in the right to information and the right to the expression of opinion, or by Prof. I. L. Kandel's analysis of education and human rights. The former bears closely on a vexed problem with which science is increasingly concerned, and the latter subject needs all the help which an objective and impartial approach can contribute.

Of the remaining essays, Aldous Huxley is most interesting in his comments on the ethical problems which confront scientific workers as individuals or as members of professional organisations, though he reminds us also that science can do something to render certain features of the general problem of human rights more tractable by diminishing the pressure of population upon resources. He refers also to the population aspect in a comment that it remains to be seen whether personal liberty, group co-operation and local and professional self-government —the three essential elements of a genuine democracy —are compatible with the qualitative deterioration of the population; but the biological approach is discussed more particularly by Prof. Gerard. Here again we find emphasis laid on the relativity of rights to the society, and on the falsehood of any doctrine which regards man only as an individual or only as a unit in a group.

What is brought out most clearly by Prof. Gerard is the dynamic character of the problem. Rights are changing, and some must be abrogated as new ones are demanded. It is imperative that provision should be made for re-examination and re-formulation at intervals. In that respect the biological approach leads us, not to the withering away of codes and laws, but to their ordered revision and adaptation to changed conditions, as Lord Justice Denning indicated in his lectures. Prof. J. M. Burgers, on the other hand, limits his contribution to the consideration of the rights and duties involved in creative expression, particularly in science, both those of the community and those of the individual and his professional group. He comments more particularly on the problems of freedom of expression and of scientific and philosophic inquiry, and in particular on the dangers which attend the introduction of legal secrecy restrictions into science.

That is a particular issue which cannot be discussed here; but Prof. Burgers shows clearly how much more is involved in it than the development of science as a pursuit of truth or its application in ways that can be adequately and ethically justified. The effects on civic rights may be far-reaching and destructive, and distrust and suspicion instead of co-operation may be caused between groups and nations. Prof. Burgers himself is prepared to accept any risks at present involved in the free communication of discoveries in what is now the forefront of scientific advance; but he seems to overlook the fact that it is reciprocity and intercommunication of minds that are responsible for stimulating creative thought and scientific advance and not just traffic in one direction.

Prof. W. A. Noyes's brief contribution is essentially a warning that the conflict between nationalistic aspirations and the need for a broader outlook will not speedily be resolved, and that certain rights of scientific workers, and consequently certain rights of man, must be curtailed for the common good. He suggests that apart from helping to eradicate poverty and disease, the greatest contribution scientific workers can make in preserving the rights of man is to educate the world into a free discussion of all matters without personal animosity. On his side, the man of science must temper his intolerance towards errors in fact and in logic with a real tolerance towards varying basic postulates in the social sphere. Prof. Noyes concludes that the immediate objective of the man of science should be to ensure that all levels of society in all nations are freed from economic anxiety; if this be done, then given a sufficient period of peace, the rights of man can be worked out and a code of ethics evolved which will fit the human race into a scientific world.

Like most of the contributors to the symposium, Prof. Noyes raises fully as many fresh problems as he discusses. Nevertheless, the symposium is a serious attempt to reach the fundamental issues; and it is above all a challenge to thought and inquiry, and a warning against any hasty or premature codification. While the contributions, in the main, concentrate attention on the general issue of the rights of man, they repeatedly indicate how important a contribution scientific workers can make to the inquiry and thought that are required for a reasoned approach to this difficult problem.

ARCHÆOLOGY AT JEBEL MOYA, SUDAN

Wellcome Excavations in the Sudan

(Published for the Trustees of the late Sir Henry Wellcome.) Vol. 1: Jebel Moya (Text). By Frank Addison; with a Chapter by A. D. Lacaille. Pp. xiv+399. Vol. 2: Jebel Moya (Plates). Pp. viii+117 plates. (London, New York and Toronto: Oxford University Press, 1949.) 2 vols., 126*s*. net.

THE aura of mystery concerning the results of the long-awaited excavations at Jebel Moya in the Gezira of the Anglo-Egyptian Sudan, which their instigator and patron, the late Sir Henry Wellcome, deliberately did nothing to dispel, is at last, after twenty-five years, extinguished by the appearance of these nobly produced volumes. Mr. Frank Addison, formerly curator of antiquities, Sudan Government, who was eventually entrusted with their publication, has had the thoroughly unenviable task of compiling the records of this long-ago enterprise of 1911–14, in which he took no part, from the field-notes and other documents of the archæologists who conducted it before the First World War interrupted, for ever as it proved, its intended continuation. That little company of archæologists, which includes the respected names of Oric Bates, James Dixon, Duncan Mackenzie, G. A. Wainwright and O. G. S. Crawford,

is itself disbanded, the first three being dead. Wainwright served for a few weeks only; Crawford in his one season conducted a separate excavation, to be published by him in a later volume.

Mr. Addison, then, in accepting publication, courageously shouldered, practically unaided, a task charged with interpretational dangers, difficulties of syntheses of sometimes badly co-ordinated records, and, above all, dubious levels. These were doubtless consequent to some extent on the seasonal change of archæologists in charge; yet they seem to have been primarily due to a fantastic excess of workmen, for which the professional staff was in no way to blame, coupled with the observance of Mr. (later Sir Henry) Wellcome's express wish that no scrap of material, however useless or undocumented, should be discarded, which must have taxed the recording staff beyond endurance. An instance of what Mr. Addison has patiently had to disentangle is revealed by the duplication in the object registers of all numbers up to 3,465, consequent upon the introduction in the third season of a new recording system which began again at the beginning.

More fundamentally serious, however, was the preliminary omission to contour the site before excavation, and control its variable but potentially useful stratigraphy (where not disturbed by numerous graves) by test trenches, and to fix once and for all well-considered datum-levels in place of the arbitrary surface-level upon which far too much reliance seems to have been placed. Inasmuch as the site lies in an upland valley basin bounded by hills, and has been subjected to unequal processes of deposition and erosion, natural and artificial, the inadequacy of depths below present surface is more than usually apparent. Mr. Addison is fully aware of this state of affairs and has evidently taken infinite care to rectify all in his power, perhaps even to the extent of over-reconstruction by methods lucidly explained. In the last resort, however, it is clear that the objects must date themselves, rather than form a stratified series which, for the undatable pottery and flint implements, would have been an invaluable and permanent contribution to Ethiopian cultural history.

Mr. Addison concludes that both the occupation of the site and the 2,800-odd graves in it may in date be contained within the last millennium B.C. An initial occupation, probably round about 1000–900 B.C., by people most probably from the Western Desert in a purely Neolithic culture stage with impressed pottery and stone artefacts, reached its zenith in the Napatan period; and direct contacts with Napata are shown by small objects including scarabs which range in style and/or period from the Egyptian late New Empire to the Twenty-Sixth Dynasty (663–525 B.C.). The site was virtually abandoned before the beginning of the Meroitic period (about 300 B.C.). The continuity of racial type, if any, will be judged by subsequent publication of the skeletal material. Much of this will be unquestioned. None the less, even an archæologist as unfamiliar with the material cultures of ancient Ethiopia as the present reviewer cannot help wondering, on studying the excellent plates, if earlier material is not perhaps included; for not only do certain bowls recall the Nubian C-group, but also some of the stone and bone artefacts, particularly the bone adzes or chisels on Pl. LVII*a*, appear closely to resemble similar objects, believed prehistoric (in the Egyptian sense), from one of Mr. A. J. Arkell's recent discoveries of two new early cultures in the Sudan.

On the other hand, the range of microlithic implements of Jebel Moya which look so archaic, and which undoubtedly first appeared in Africa at a remote period, need occasion no surprise in late contexts such as Jebel Moya. They include elements in common with obsidian and chert microliths found by the reviewer in tombs in South Arabia dated by seals showing Achæmenian influence, and which probably date to Achæmenian times[1]. South Arabian contacts with Ethiopia at much the same period are suggested also by the small pottery vessels referred to in the Jebel Moya publication as "spouted feeding-cups", which are believed to date there to the latest period of occupation. Some attention is given to their geographical connexions, and the closest parallel cited is a French Neolithic settlement. It is unnecessary to travel so far in space and time, when the Hadhramaut tombs, already quoted, produced similarly tubular-spouted vessels which, though not identical in detail and more sophisticated, are closely akin. One of them was inscribed "perfume" in Himyaritic characters[2].

G. CATON THOMPSON

[1] Caton Thompson, G., "The Tombs and Moon Temple of Hureidha, Hadhramaut". Report of the Research Committee, Society of Antiquaries, **13**, 93 (1944).

[2] *Ibid.*, 124.

SCHOOL SCIENCE IN AMERICA

New Directions in Science Teaching

A Report of a Cooperative Project in Seventeen Secondary Schools with the Bureau of Educational Research in Science, Teachers College, Columbia University. By Prof. Anita Duncan Laton and Prof. Samuel Ralph Powers. Pp. xi+164. (New York and London: McGraw-Hill Book Co., Inc., 1949.) 15*s*.

THIS book describes and interprets the experiences of a widespread group of American teachers who co-operated with the Bureau of Educational Research in Science in applying modern educational theory concerning project and activity methods, and the applications of studies to the problems of living, to the education of 'senior high school' children (the nearest equivalent in Britain would be the secondary modern schools). Account has been taken of recent advances in educational theory and science, including investigations in growth and development of children, use of community resources, the learning process and group planning.

The method used in this small book is to take the ideas of outstanding science teachers in schools in various parts of the United States. The ideas are tried out by research associates in 'curriculum workshops', and there is a list of external consultants which is quite impressive. The book does not give instruction in the techniques of science teaching in classroom, lecture room or laboratory, and on the whole it deals merely with themes and topics. An example of the methods employed is shown by this extract: "The School nurse at George Rogers Clark School in Hammond found, by questionnaire, students' ideas of care of illness. She discovered, for example, that students thought one could cure a cold by 'wearing it out', taking aspirin, taking a good dose of whiskey, taking castor-oil or going to bed. Similar beliefs were found as to the cause and treatment of headaches and other minor ailments. These beliefs helped shape the teaching of the course in biology where stress was given to problems of home nursing." The Denby High School lists three fundamental needs: (1) the development of a long-range social

point of view based on scientific principles; (2) the development of a desire to do something about social problems; (3) the development of ability to work co-operatively on the analysis and solution of problems. In the schemes of work there is an attempt to integrate the science subjects and also to achieve a newer synthesis of the sciences with other branches of knowledge such as the social studies, history, English, and so on.

All this is not new to the progressive teacher in a British secondary school, where 'reality in the classroom', 'projects' and social studies are being developed. Such treatment is particularly useful for the non-specialist in science, but it may be that a word of warning is necessary. Since 1902 a general high level in science has been built up in British grammar schools, and many of the 'public schools' have a somewhat longer tradition in these matters. No doubt 'project' and 'reality' methods can effectively replace the old 'heurism', and there is still room for a wider knowledge of the applications of science to the improvement of society; but the loss to science standards in Great Britain would be incalculable were anything to replace the sound training in fundamental principles and laboratory measurements which has characterized most of the grammar school science during more than four decades.

W. L. SUMNER

A CHEMICAL TECHNOLOGIST LOOKS AHEAD

Farmer Victorious

Money, Mart and Mother Earth. By William J. Hale. Pp. xii+241. (New York: Coward-McCann, Inc., 1949.) 3 dollars.

THE author of this book, Dr. W. J. Hale, was chairman of the Division of Chemistry and Technology of the National Research Council, Washington, D.C., and is now consultant to an important American chemical company. Like many others, he feels that the blessings that our fathers expected from the enormous developments of science and technology have not materialized; something has gone wrong. He considers he has discovered the fault—the money-lending on which the trading and banking systems of the world are based. The elimination of this fault requires the abolition of international trade and the re-organisation of the nations of the world into four blocks or sections: Anglo-American, Latin-Teutonic, Slav, and Mongolian, each of which would be self-sufficing and would have no occasion to trade with the others, though some tourist traffic would apparently be permitted. All small nations would simply disappear; the pound sterling would vanish and be replaced by the dollar, the U.S.S.R. would be encouraged to expand still further and acquire "a deep southern domain", and Africa would largely become an appendage of the Latin-Teutonic section. India is not mentioned, being apparently too small for consideration. With all this part of the story, and the denunciations of business men, "crackpot" politicians, and the supposed "tame" scientific workers who meekly obey them, we need not concern ourselves.

The technological part of the book is based on the thesis that the farm is a much better source of raw materials for the chemical manufacturer than coal or oil, inasmuch as its resources are inexhaustible. "We need to apply ourselves more diligently," the author says, "to harness the four million kilo-watt hours of the sun's energy that falls daily on every square mile of the earth's surface." The statement is typical of the whole book. The plant synthesizes carbohydrates which can be fermented to produce ethyl alcohol, which is not only an excellent source of power but also a starting material for making synthetic rubber and many other things. Oat hulls and corn cobs yield furfurol, out of which nylon can be made; castor oil seems even more promising. Each type of plastic, however, requires its own crop. Factories should be set up to deal with all farming products, even weeds; direct food production would become a subsidiary activity, and meat would be replaced by synthetic amides. Such food as was grown must be produced without the use of synthetic fertilizers; only composts, the trace and 'basic' elements, and, apparently, nitrogenous fertilizers, being permitted. A special chewing-gum would ensure ample supplies of vitamins and other essentials.

Those interested in blueprints for the 'New Age' may like to add this to their collection; it differs from those of Aldous Huxley, Vogt and Osborn in forecasting illimitable supplies of farm products which can be worked up into all things needed by man, though it does not say how these vast quantities can be obtained.

E. J. RUSSELL

ELECTROMAGNETIC INDUCTION

Faraday's Discovery of Electromagnetic Induction

By Thomas Martin. Pp. 160+4 plates. (London: Edward Arnold and Co., 1949.) 9s. net.

MICHAEL FARADAY carried out the greater part of his experimental researches within the Royal Institution, Albemarle Street, London, and it was characteristic of him that he made notes, in diary form, of his investigations and occasionally his speculations. Mr. Thomas Martin, general secretary of the Royal Institution since 1929, edited the printed version of "Faraday's Diary" published during 1932–36 in seven volumes. While engaged on this task, Mr. Martin delved deeply into Faraday's published papers and other contemporary and later sources of information. In the present little work, he has selected one of Faraday's major investigations—and perhaps his most important—namely, electromagnetic induction, and presented it in the light of contemporary views of the nature of electricity and magnetism. By quoting extensively from the "Diary", he enables the reader to follow Faraday's thoughts and work on the subject over a period of years, culminating in about six months of almost continuous work in late 1831 and early 1832 which served to establish the main facts of electromagnetic induction, the basis of modern electrical engineering. Having discovered the effect on August 29, 1831, Faraday quickly verified his observations, and then passed on to obtain a flow of induced electricity by means of a rotating copper disk and finally extended the work to induction by the earth's magnetism.

The book is illustrated by reproductions of many of the quaint little sketches drawn by Faraday in his notes and by photographs of apparatus he used which is still in the keeping of the Royal Institution.

THE HARWELL CYCLOTRON

By T. G. PICKAVANCE, J. B. ADAMS and M. SNOWDEN

THE cyclotron at the Atomic Energy Research Establishment, Harwell, on which work was started in the autumn of 1946, has been operating since the beginning of December 1949, and is producing protons of energy about 180 MeV. It is of the frequency-modulated type first developed by E. O. Lawrence's team in the University of California[1].

The application of frequency-modulation has greatly increased the energy to which particles can be accelerated in a cyclotron. In the ordinary cyclotron, ions are accelerated in spiral orbits in a uniform magnetic field by the repeated application of a potential difference from a fixed-frequency oscillator. The frequency of the accelerating voltage must be synchronized with the circulation of the ions in their orbits. However, the angular velocity of charged particles moving in a uniform magnetic field decreases with increasing energy, on account of the relativistic increase of mass, and this effect becomes serious in practice at a velocity of about one-tenth that of light. The ions suffer a growing phase-lag with respect to the accelerating voltage, as their velocity increases, and this is made worse by the necessity for focusing the ion beam towards the median plane of the magnet gap; the only effective method of doing this is to arrange for the magnetic field to decrease slightly with increasing radius. If, therefore, we were to attempt to synchronize the orbital motion of the particles by increasing the magnetic field with the radius, we should lose the beam through the strong defocusing action of the magnetic field. Without attempting any form of synchronization, but by using a high accelerating voltage (100–200 kV.), particles may be accelerated to about 10 MeV. for protons, 20 MeV. for deuterons or 40 MeV. for the doubly-charged helium nuclei. This limit corresponds roughly to a cyclotron of 60 in. diameter.

A means of overcoming this difficulty was suggested independently by Veksler[2] and McMillan[3], who showed that charged particles circulating in a cyclotron may possess the property of phase stability. Under certain conditions a particle can travel in a stable orbit, oscillating in phase, radius and energy with finite amplitudes about equilibrium values determined by the magnetic field, the frequency of the electric field and the ratio of charge to total mass of the particle. Veksler and McMillan showed that, by slowly increasing the magnetic field with time, reducing the frequency, or both, the orbit can be made to expand and the energy to increase. M. L. E. Oliphant independently proposed a similar method of accelerating particles (unpublished). In all accelerators based on these principles, the particles can remain in synchronism with the accelerating field despite the relativistic increase of mass and the shaping of the magnetic field for focusing, and in practice the energy obtainable is limited by economic rather than technical considerations. In the frequency-modulated cyclotron, or synchro-cyclotron, the magnetic field is fixed and the frequency of the accelerating voltage is progressively reduced during acceleration. Acceleration begins when the frequency has the correct value for ions of low velocity, and continues until the frequency has reached the appropriate value for the final conditions of magnetic field, orbit radius and particle energy. The frequency is varied cyclically, and the particles reach the target in pulses, at intervals determined by the repetition-rate of the frequency-modulation cycle.

The 184-in. California cyclotron has been producing about 1 microampere mean current of 190-MeV. deuterons and 350-MeV. protons for some time, and valuable research has been carried out by its use. Other large cyclotrons are operating or under construction in the United States, and several are being built in Europe. The Harwell cyclotron is the largest so far operating in Europe, and will be the only one of its kind in Britain until a new and larger cyclotron has been built in Liverpool.

The Equipment

The magnet of the Harwell cyclotron has straight-sided poles, 110 in. in diameter and 12 in. apart. The yoke and poles are built of 670 tons of low-carbon steel in 10-ton plates, and the windings contain 70 tons of copper strip, are oil-cooled and consume 355 kW. for the normal centre field of 16,500 gauss. The pole faces are contoured in such a way that the vertical component of magnetic field falls off approximately linearly with increasing radius, from the centre to as great a radius as is practicable, to provide adequate magnetic focusing for the ion beam; the maximum usable radius (expected, according to the Berkeley results, to correspond to $n = 0{\cdot}2$, where $n = -\frac{r}{H}\frac{\partial H}{\partial r}$) should be 50·4 in., and the magnetic field at this radius is 15,725 gauss. A stainless steel vacuum chamber is sealed to the sides of the magnet poles, and is evacuated to a pressure of less than 10^{-4} mm. mercury by oil-diffusion pumps with a speed of 10,000 litres per second; the total volume of the vacuum system is about 12,000 litres.

A single copper accelerating electrode (the 'dee') is mounted between the magnet poles, with a grounded copper sheath which concentrates the electric field and effectively forms a second 'dee'; the 'dee' is connected to a system of resonant coaxial transmission lines coupled to a single 150-kW. triode valve to form a grounded grid oscillator. One of the 'dee' lines is terminated by a motor-driven variable condenser, which varies the resonant frequency over the range 26·5–20 megacycles per second for the acceleration of protons and is placed in a region of low magnetic field, to avoid eddy-current losses in the rotating parts. The whole of this circuit is water-cooled, and the lines and condenser are included in the main vacuum system. A D.C. bias voltage can be applied to the 'dee' and lines, for the collection of stray electrons which would otherwise oscillate in the radio-frequency field and produce discharges, heavily loading the oscillator.

The protons are produced by a low-voltage filament-maintained arc discharge in an ion source at the centre of the magnet poles, in the accelerating gap between the 'dee' and its grounded sheath. An adjustable probe-target may be set at any distance from the centre, so that the proton beam may be intercepted at any desired energy. Apparatus up to

about 8 in. cube may be inserted through an air lock, for irradiation on the probe, without disturbing the vacuum.

Elaborate shielding is needed, since the neutrons ejected from the target by the proton beam are very penetrating. The cyclotron is installed underground, with a 6-ft. thickness of concrete overhead, and is remotely controlled by a system incorporating safety interlocks and protective devices.

Performance Characteristics

The cyclotron is being operated with a peak 'dee' potential of about 5·5 kV., obtained with 12 kW. average D.C. input power to the oscillator, and a D.C. 'dee' bias of 500 V. is sufficient to prevent discharges. The average acceleration per traversal of the 'dee' gap is about 3 kV. Under these conditions, the protons circulate about 30,000 times in travelling from the ion source to a radius of 50 in., to acquire a kinetic energy of a little less than 180 MeV., corresponding to about half the velocity of light. In contrast, the number of circulations in a conventional cyclotron with fixed frequency is usually about a hundred, with a much higher 'dee' voltage and radio-frequency power.

The frequency-modulation cycle is repeated at a frequency of about 80 cycles per second, so that the beam pulses are separated by about 12 milliseconds; the duration of the beam pulses varies with the operating conditions, but is usually of the order of 100 microseconds. The beam current is not very sensitive to variation of the repetition-rate or to small changes in the magnetic field; but under the present conditions of operation it rises rapidly with increasing 'dee' voltage. It is planned eventually to increase the 'dee' voltage to 12 kV. and the repetition-rate to 200 cycles per second. At present the mean beam current is about 0·5 microampere, which may be considered satisfactory for a frequency-modulated cyclotron in the initial stages; it should be considerably increased as development continues.

Measurements of the neutron and γ-ray intensities outside the cyclotron pit show that the shielding is adequate, and that it has a considerable safety margin for operation at higher beam currents. A preliminary measurement of the fast neutron output gives a value about 10^{10} neutrons of energy above 50 MeV. per unit solid angle per second, in the centre of the neutron beam produced by proton irradiation of a copper target. A bismuth fission chamber, which is only sensitive to neutrons of above 50 MeV., was used in this determination.

Programme of Work

At first, a considerable proportion of the running time will be devoted to development of the machine, with the object of increasing the beam current and extracting the beam. Some work has already been done on the extraction problem; but many experiments can be done using an internal beam. In particular, neutron experiments can be performed in this way; a fairly well-defined beam of neutrons of energies ranging up to the full proton energy is produced when the protons fall upon an internal target, and a thin window in the wall of the vacuum chamber allows the neutrons to enter the detecting apparatus outside, with negligible attenuation and scattering.

The first neutron experiments will be measurements of the total cross-section for attenuation of neutrons by a wide range of elements as a function of neutron energy. Since these experiments will involve a measurement of the energy distribution of neutrons produced by 180-MeV. protons, in various targets, they will provide a basis for further work with neutrons.

At the full energy of 180 MeV., it should be possible to produce mesons, and attempts will be made to observe them in photographic emulsions. The yield of mesons at this energy is known to be rather small, and therefore it is planned to spend only a small proportion of running time on meson experiments. Other experiments with photographic plates will be concerned with nuclear explosions produced by protons and neutrons, and similar work will be done with cloud chambers. These very high-energy nuclear reactions will also be investigated by radiochemical methods, and there is a small 'hot' laboratory, connected to the cyclotron by a pneumatic delivery system for handling short-period activities.

We wish to acknowledge the valuable assistance of many industrial firms, in particular of Messrs. C. A. Parsons and Co., Ltd., who constructed the magnet, which was the biggest industrial contribution. The more specialized parts of the cyclotron were built by the Engineering Division at Harwell, and civil engineering and electrical work were done by Ministry of Works contractors.

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CRAZING OF CAST POLYMETHYL METHACRYLATE*

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THE phenomenon of crazing of brittle plastics is one to which frequent allusion is made in the technical literature, but which has been little studied in detail. It has been defined[1] as "fine cracks which may extend in a net-work over or under the surface of or through a plastic". In transparent plastics, the cracks are readily visible to the naked eye by reflexion from their surfaces and appear as bright lines or spots as the specimen is held at varying angles to the incident light. The effect has been ascribed to the volatilization of monomer or other volatile impurity in the material, and also to internal stresses[2]. It has been observed[3,4] in polymethyl methacrylate, polystyrene, cellulose derivatives and some vinyl polymers. A similar effect has been described in phenolic resins exposed to acetone[5].

The practical importance of crazing lies in the change of properties which it produces. Light transmission may be reduced by it when present as a haze, and, by distracting the attention of the viewer, local patches of crazing may interfere with vision at times when rapid and accurate identification of objects is essential. Furthermore, surface defects

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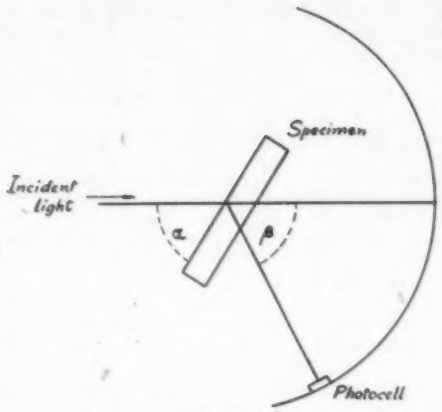

Fig. 1

influence the structural properties of the material. The high notch-sensitivity prevents the attainment of the designed strength of a structure, so that such defects must be regarded as incipient failure. Also, according to Bartoe[6], very small changes in the depths of scratches are accompanied by large reductions in impact strengths.

Forms of Crazing

A great variety in the form and disposition of the system of cracks is observed, depending on the conditions under which the crazing is produced. The size of the cracks may vary from those visible directly to the naked eye to those which are apparent only as haze or translucence producing scattering of light.

Deeg[7] studied the permeability to water vapour of plastic films and showed that crazing, like porosity, gave erroneous results. Vieweg and Schneider[4] measured the distribution of light transmitted by plates of polystyrene oriented at various angles to the incident beam. They found in addition to the maximum by direct transmission a second maximum in the light intensity at angles such that $180° - \beta = 2\alpha$ (Fig. 1). This they attributed to reflexion by internal inhomogeneities, which they showed microscopically to consist of small cracks preponderantly perpendicular to the face of the samples. When a crazed sample is immersed in a good solvent, the polymer breaks up along the lines of the worst crazing before swelling and dissolution is complete. This suggests that penetration occurs through cracks which have been produced at those points. There is thus evidence that crazing consists of fine cracks; other facts in agreement with this hypothesis will emerge.

The variety of the patterns produced by the crazing of polymethyl methacrylate when viewed under the microscope is most marked. There are two main groups of conditions for the production of the effect, and the differences between them become more evident when so observed. The application of large mechanical stresses to the material is characteristic of one such group (*stress crazing*); in the other, crazing is induced by the action of chemical agents (*solvent crazing*). These two types are not mutually exclusive, so that the effect may be produced by the simultaneous action of stress and solvents; internal stress is, in fact, essential to crazing under the influence of solvents.

When subjected to mechanical stressing, methacrylate samples craze on those faces which are in tension. Purely compressive stresses do not produce the effect. The direction of the fissures is at right angles to that of the applied stress. Such a pattern viewed by normal transmitted light (× 35) is shown in Fig. 2. The physical dimensions of the crazing pattern appear to vary with the sample thickness, though the control of other variables is difficult and introduces some uncertainty into this conclusion. Gross crazing is observed in thick test pieces, whereas a fine haze occurs in thin films which under sufficiently high magnification is similar in appearance to Fig. 2. A highly plasticized material exhibits grosser crazing than the unplasticized polymer. Monomer in an incompletely polymerized product behaves as plasticizer, and therefore heat treatment causing further polymerization of the monomer markedly lowers the tendency of such a sample to craze.

Certain samples craze when exposed to the action of some liquids or their vapours. Any liquid which will swell or dissolve the polymer can produce this effect; with good solvents the effect is almost instantaneous.

The system of fissures produced by solvent attack is apparently randomly oriented, unlike those produced by directional tensile stressing. The cracks appear to start at a series of separated points, usually as a *V*- or *Y*-shaped mark from each; such incipient crazing is shown in Fig. 3. These cracks then join up to form a continuous pattern of varying coarseness. On prolonged exposure, swelling of the polymer disturbs the whole surface and the effect of the cracking is masked. The final stage of breaking up before dissolution is readily visible to the naked eye.

An important observation is that the clear surface obtained by breaking a cast sheet failed to craze, although the original surfaces both crazed badly on exposure to solvent. Cut and polished edges behaved similarly, but local heating during the finishing process may have minimized any possible effect.

When the methacrylate is subjected to a tensile stress of a lower magnitude than that required to induce normal stress crazing, the effect of vapour is enhanced. This combined effect of stress and vapour has been used to test[8] the crazing resistance of material and the crazing effects of various agents upon it. Conversely, the crazing of polystyrene in solvent has been used[9] to follow the annealing process

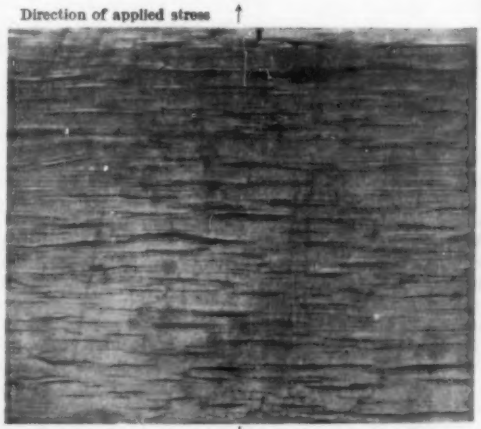

Fig. 2. Stress crazing (× 35)

Fig. 3. Solvent crazing (× 35)

in removing stresses. For relatively high stresses the direction of the fissures is again perpendicular to that of the stress. For lower values a variety of patterns is observed as the two types of crazing are to a certain extent superimposed. A swollen polymer, even if it has not crazed during the absorption of solvent, exhibits very coarse cracks when stressed, a result essentially the same as when a plasticized polymer is stressed in the absence of other solvent.

Theory of Crazing

Some evidence has been given that, in crazing, actual cracking of the polymer surface occurs. Since a broken or cut surface does not show the effect in solvent vapour, the original cast surface and the zone beneath it must be a system containing all the factors necessary to crazing. It appears reasonable to assume that the fissures are produced by the same processes as are involved in normal tensile failure, and that the surface zone contains non-uniform randomly directed stresses which must have their origin in the past history of the material, that is, in the casting process.

Material polymerized below its ultimate second-order transition temperature contains molecular chains in a state of strain, and such material absorbs vapour more rapidly than that containing chains which are relaxed. Thus portions of the material become plasticized locally and incapable of supporting the proportions of the stress carried initially. This is thereby concentrated on to other stressed portions until the critical conditions for failure are reached. By a repetition of the process, local fissures are formed until the stress is relieved. The random distribution of the cracks observed in solvent crazing follows from the postulated random orientation of the stresses.

If an increasing uniform tensile stress is applied, the resultant stress within the surface is the sum of that stress and the component in the same direction of the internal one. Thus the critical conditions for fracture are attained locally before they are realized throughout the bulk of the material at ultimate failure. Only that component is now effective; and the cracks produced are perpendicular to it.

Rate of Solvent Absorption

From the postulated mechanism of crazing, a high rate of solvent absorption should be an important factor." Slow absorption should permit the relaxation of the surface stresses without sufficient local plasticization being reached to permit their concentration locally and the consequent failure of the more highly stressed material.

A sample of commercial polymethyl methacrylate sheet containing 8 per cent of dibutyl phthalate was heated to 35° C. in an evacuated system. Benzene was then introduced into the system and its vapour pressure was slowly increased by raising the temperature of the liquid in the coldest part of the apparatus from 0° C. to 27° C. during several days; absorption occurred slowly and without crazing. With a fresh sample of the same sheet the benzene temperature was rapidly raised by plunging the liquid into a thermostat at 27° C.; crazing was extensive within a few seconds. In the light of this result it is of interest to examine the conditions under which solvent absorption is rapid.

Baughan[9] observed marked hysteresis in the absorption of carbon tetrachloride by polystyrene; below a relative vapour pressure of 50 per cent no absorption could be detected. In the course of experiments on polymethyl methacrylate, similar effects have been observed for a number of systems. The accompanying table gives approximate values of the relative vapour pressure (p/p_0) of benzene necessary for appreciable absorption during one day by films held at 35° C.

Percentage dibutyl phthalate plasticizer	p/p_0 for 1 per cent absorption by weight
0	93
8·0	56
18·2	32

These figures show that the increased mobility of the polymer chains conferred by the plasticizer markedly lowers the resistance of the material to attack by moderate concentrations of vapour.

Stretching the heated polymer, followed by cooling to freeze in the deformation, greatly enhances the rate of absorption. This result is analogous to that considered by Flory[10] and Gee[11] on the swelling of stretched rubbers; greater swelling is to be anticipated, and the rate of swelling at any instant may be assumed to depend on the extent to which the sample can swell further. Fig. 4 illustrates the effect of stretching films at 140° C. on the absorption of acetone at 35° C. while a constant relative vapour pressure of acetone of 82·5 per cent is maintained.

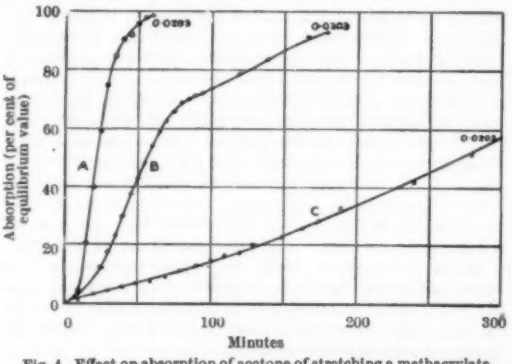

Fig. 4. Effect on absorption of acetone of stretching a methacrylate film. (*A*) 53 per cent unidirectional stretch; initial thickness, 0·0203 cm. (*B*) 22 per cent unidirectional stretch; initial thickness, 0·0203 cm. (*C*) Heated for 4 hr. at 140° C.; initial thickness, 0·0202 cm.

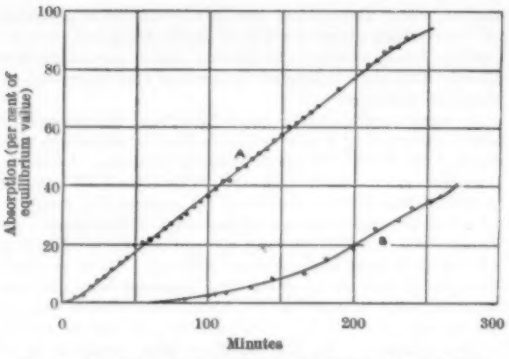

Fig. 5. Absorption of acetone by methacrylate before and after desorption. Initial thickness, 0·0236 cm. (*A*) Fully polymerized at 60° C. (*B*) Fully polymerized at 60° C.; desorbed and absorption repeated

With films which had been completely polymerized at 60° C. between glass by maintaining them at that temperature for at least four days, the absorption-rate (Fig. 5, curve *A*) greatly exceeded that of material heated at 140° C. (Fig. 4, curve *C*). Trommsdorf[12] found that, at 60° C. with 0·02 per cent benzoyl peroxide, polymerization was complete after 48 hours; the present samples contained 0·1 per cent peroxide and were heated for twice that period. After equilibrium was reached, solvent was removed by lowering the vapour pressure and raising the temperature. The original film weight was regained within 0·02 per cent. The absorption was then repeated (Fig. 5, curve *B*). By this method, initial film thicknesses and areas were constant, allowing a direct comparison to be made. The weight fraction of solvent in the film at equilibrium agreed in each case with that obtained under similar conditions with the pre-heated film. This, together with the fact that the original weight was obtained after desorption, is evidence that polymerization was complete, and the enhanced rate for the polymer cast at 60° C. between glass was not due to the presence of monomer. The similarity between the absorption curves for stretched films and for those polymerized at 60° C. suggested that the latter are effectively in a state of tension, and that the effect of heating or of solvent absorption is to permit relaxation. Even after several hours of heating at 140° C. in a deformed state, recovery is nearly complete if the deforming stress is removed and the temperature raised a few degrees. Thus chain entanglements limit the viscous flow of chains over one another and the relaxation of highly elastic strains to free portions. On absorption of sufficient solvent, however, chains are separated and allowed to assume a random configuration, and they retain this on desorption. In agreement with this theory it is observed that films heated for 4 hr. at 140° C. showed immediate absorption (Fig. 4, curve *C*), whereas comparable desorbed films showed a pronounced delay before absorption commenced (Fig. 5, curve *B*). That the condition of polymerization in contact with the glass surface is not responsible for the large difference in absorption-rates before and after relaxation is shown by the fact that similar differences were observed in a film completely polymerized on mercury.

Summarizing, plasticized polymethyl methacrylate is more susceptible to attack by moderate concentrations of vapour than is the unplasticized material. The rate of absorption is enhanced by the presence of frozen-in strains of the highly elastic type such as occur at points of high curvature in articles formed from sheet material at elevated temperatures.

Polymer stretched at ordinary temperatures by external stressing alone should absorb solvent at an enhanced rate. From the law of mobile equilibrium, the effect of the strain is to increase the swelling to counteract it, and we may assume as before that the rate of swelling depends on the extent to which the sample can swell further. This can be shown as follows: a sample was selected which when exposed to volatile solvent did not craze even on subsequent stressing. However, on maintaining the stress while applying the solvent, crazing was instantaneous. Within the time of exposure when unstressed, absorption was inappreciable; when stressed, the rate became rapid.

Relation of Second-order Transitions to Crazing Phenomena

The observation that heat-treated methacrylate is less susceptible to solvent crazing suggested that, in addition to the effect of completing polymerization, surface stresses initially present are removed. It was anticipated that heating just above the second-order transition temperature for a short time would remove such stresses; more prolonged heating was required to complete polymerization, as was shown by shrinkage-time measurements.

Samples of commercial material containing 8 per cent plasticizer and 3·3 per cent of residual monomer were exposed to benzene vapour at room temperature after heating each for 2 hr. at one of a range of temperatures. At 40° C. no alteration in crazing occurred; at 50° C. it was somewhat reduced, and at 55° C. became very slight. At 60° C. none was observed; but less than half of the residual monomer was polymerized. For this material the transition temperature initially was 51° C., rising with the disappearance of monomer to 78° C. As a matter of interest, a transition point between 50° and 60° C. was predicted from these results before the determinations were made by the usual dilatometric method. It was concluded from these experiments that stress as postulated is a necessary condition for solvent crazing. There is no evidence that monomer is essential to the crazing mechanism. A fully polymerized material when sufficiently stressed will absorb solvent, and crazing appears.

The critical conditions for failure under external stress could conceivably be attained by stress concentration at local surface defects, such as are considered to initiate the failure of crystals and of glasses. Consideration of the local conditions when a uniform tensile stress alone is imposed shows that any local failure started in this manner should be self-propagating to result in complete rupture, inasmuch as such failure produces increased concentrations of stress. It is therefore improbable that such defects are the sole cause of local failures distributed over a surface. Since the non-uniform surface stresses regarded as necessary for crazing under externally applied stress are relaxed at the second-order transition point, this should represent an upper temperature limit for the effect to occur. Completely polymerized methacrylate samples were heated and rapidly stressed at a range of temperatures; no crazing was observed above the second-order transition point, although it could be produced below that temperature.

Elastic Deformation in Relation to Crazing

Many authors have considered a general deformation of a polymer as the sum of a number of separate components of differing mechanism. The total response to stress is composed[13] of instantaneous elasticity, retarded configurational elasticity and flow. The instantaneous 'ordinary' elastic component results from the separation of molecular chains and the deformation of molecules by changing the normal valency angles between the bonds and/or the bond-lengths. The highly elastic deformation arises from changes in the shape of the molecules by a time-dependent re-orientation of the chains, and the time-dependent flow results from the irreversible slipping of chains along one another altering their relative positions; in the case of polymethyl methacrylate, this is negligible at room temperatures. Also, at this temperature, unplasticized methacrylate is about 80° C. below the transition temperature, so that the highly elastic factor is not predominant in the short time occupied by a normal laboratory tensile test. Thus under these conditions the major deformation leading to fracture must result from the 'ordinary' elastic component. Hence it is concluded that crazing is induced by the presence within the material of 'ordinary' elastic strains resulting from the stresses already considered. Alfrey[13] defines as true internal stresses those in which "one part of the object pulls or pushes against another part and because of the geometry of the system these forces cannot be relieved". Frozen-in highly elastic strains experimentally give no indications of crazing. Alfrey points out that in these cases the internal stress commonly referred to does not have the physical significance of a true stress. Samples recover their original shape on heating because the internal Brownian movement produced brings them to the most probable condition.

Meyer[14] discusses the rupture of polymers and considers the effects of breaking the molecular chains and of slipping of the chains over each other. In the latter, intermolecular forces are overcome, and irreversible deformation leads to necking and ultimately to breakage and is favoured by a slow rise in tension. With very high molecular-weight polymers such as cast polymethyl methacrylate (molecular weight $\simeq 1\text{–}2 \times 10^6$) long portions of the chains have to slide over each other for failure, and it becomes easier to rupture primary bonds than to overcome the increased intermolecular forces. A rapid rise in tension favours chain rupture. These considerations agree with the above conclusion that primary-bond deformation is produced in the methacrylate sheet.

Molecular Orientation and Crazing

In a recent paper, Sauer, Marin and Hsiao[15] have suggested that crazing is essentially an orientation phenomenon and not one of mechanical crack formation. The latter, on this theory, is only an associated phenomenon if the applied stresses are high enough to produce fracture. X-ray diffraction results are adduced as evidence for orientation in the direction of stretching of crazed polystyrene. Unstretched material is considered to exhibit random orientation of geometrically ordered regions in the otherwise amorphous structure. These authors used polarized light to detect residual stresses in their material, rejecting those sheets showing evidence of such internal stresses. They concluded that crazing occurs where no appreciable residual stresses are present.

Considering the above evidence, it is seen that X-ray diffraction detects orientation which is not detected by polarized light. Particles which are optically anisotropic may be too fine to show appreciable retardation individually according to Chamot and Mason[16]. Moreover, the effects of local tensile stresses and the equivalent compressive stresses tend to cancel each other. Inasmuch as random orientation is evidence of the effect of randomly directed forces, the theory that the latter are responsible for crazing does not appear to be invalidated.

The suggestion that the visual effect observed in crazing is due to orientation alone requires further examination. No change in transparency of sheet material is observed on hot stretching, when more orientation is to be anticipated than in a tensile or creep test, and such material is not susceptible to crazing. Also, for all the cases examined the haze observed is resolved under high magnifications into a pattern similar to the more obvious cracks visible at low magnifications. It is concluded that crazing and orientation are both effects of tensile forces but are not identical.

Observations on Fracture

Experimentally, the conditions for fracture are attained locally in the surface before failure of the bulk of the material. Crazing is produced at a stress considerably lower than the ultimate strength, and there is evidence that for a given sheet at each temperature this is a more or less constant proportion of the load at fracture.

The reverse bending of a specimen already crazed under bending caused the disappearance of the visible effect. In this connexion Haward's[17] results on cellulose acetate are of interest. He showed that extension produced a whiteness and opacity which he attributed to hole formation. Extension of the material under a load, applied for a time insufficient to break it, permanently weakened the material even after the deformation was removed by heat. Re-application of the load produced early failure, and the total time of application was approximately constant independently of how it was subdivided. In methacrylate the healing of cracks by the entanglement of molecular chains when two surfaces are mechanically pressed together is improbable, and a similar weakening is to be anticipated though visible crazing has disappeared. This was shown by the following experiment: a sample was crazed by bending; on removal of the stress the sample was heated at 100° C. until all traces of crazing disappeared and was then allowed to cool. On re-stressing, crazing was rapid; if the original pattern was produced in a characteristic shape by wiping the stressed sample with volatile solvent, the same shape was re-formed.

Origin of Surface Stresses in Cast Sheet

It has been shown that the stresses remaining in commercial methacrylate sheet to produce crazing must arise at some stage of the casting process. The sheet is produced by completing the bulk polymerization of partially polymerized syrup in glass cells at a slightly elevated temperature. Since, in order to sustain a stress, a high extent of polymerization is necessary, only the later stages of the process need be considered. A possible cause of tensile stresses near the skin can now be advanced.

The polymerization reaction is highly exothermic, and unless adequate heat transfer occurs, the temperature of the reacting mass may rise considerably above that of the surroundings. The thermal conductivity of the polymer is insufficient to maintain a uniform temperature throughout the sample, and the centre is therefore at a higher temperature than the polymer–glass interface. Hence, until polymerization is complete, the extent of conversion is greater in the bulk of the material than at the surface. The reaction proceeds with considerable shrinkage (about 26 per cent for methyl methacrylate), so that greater shrinkage occurs within the material than in the outer portions. So long as sufficient monomer remains in these latter zones to permit chain mobility, no stresses are produced. Further reaction shrinks this shell on to the inner more fully polymerized material, compressing the latter and leaving the surface in tension.

Tensile stresses do not remain in the material if it is heated above the second-order transition temperature. Irregular cooling of the material from above this temperature gives rise to density gradients throughout the mass. Since the surface cools more rapidly than the bulk, the density of the latter is the greater; compressive stresses in the surface result, and these do not produce crazing. Such material should, in fact, be craze-resistant, as is the case with properly heat-treated material. Tensile test specimens, appropriately heat-treated after preparation, failed under normal rates of loading without crazing even in the form of haze. Non-uniform stressing, for example, in bending, readily produced crazing on heat-treated specimens.

It has been shown that the stresses may be removed from an incompletely polymerized sample by heating. When now the same material was heated at 60° C. for a prolonged period so as to complete the polymerization at a temperature below the ultimate second-order transition point, crazing could once more be produced by the application of solvent. Similarly, heat-treated polymer, which did not craze with the solvent, could be caused to craze under those conditions after polymerizing the monomer which it was allowed to absorb by immersion. This is attributed to the re-introduction of tension into the surface by polymerization shrinkage. Such further polymerization with the production of the stresses needed for crazing may occur under suitable conditions of prolonged storage.

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MORPHOGENESIS IN PLANTS AND ANIMALS

At a meeting of the Linnean Society on November 24, under the presidency of Prof. F. E. Fritsch, Profs. Eric Ashby and C. W. Wardlaw, of the University of Manchester, gave an account of experimental investigations which they have been conducting on morphogenetic processes in plants, while Prof. G. R. de Beer, of University College, London, contributed a commentary on comparable phenomena in animals.

The discussion opened with a paper by Prof. Ashby and Miss E. Wangermann on morphogenesis in *Lemna minor*. The aim of the work described was to study by quantitative methods the rate of ageing of a plant grown under controlled conditions. *Lemna* was selected for the work because it can be grown conveniently in the laboratory and because a frond has a finite expectation of life (about forty days) during which it produces a finite number of daughter fronds (some five or six). There is a decrease in size from one daughter frond to the next, so that a fourth daughter frond, for example, is only one-fifth as large as a first daughter frond. This decrease in size is used as a measure of the rate of ageing. Factors (such as the presence of 2·5 mgm. per litre of heteroauxin), which shorten the expectation of life of a mother frond, at the same time increase the rate of diminution of size from one daughter frond to the next; and the rate of diminution of size between daughters corresponds to the rate of ageing of the mother.

In order to determine the cause of the decrease in size of successive daughter fronds as the mother frond becomes older, Prof. Ashby and Miss Wangermann carried out experiments designed to test whether (*a*) the mother frond produces a growth-promoting substance which diminishes in concentration as the frond ages, or (*b*) the mother frond produces a growth-inhibiting substance which increases with its age. The experiments demonstrate that the mother frond promotes, and does not inhibit, the growth of its daughters. If all but a fifth of the mother frond is cut away, the daughter fronds still receive enough of the growth-promoting substance to enable them to grow almost to their normal size. Preliminary experiments indicate that the growth-promoting substance is not heteroauxin.

Prof. Wardlaw illustrated the structure of large apices of ferns such as *Dryopteris tristata*, and pointed out that the leaf primordia, which constitute a very regular phyllotactic sequence, are widely spaced around the base of the apical cone or growing point. Bud positions may be described as axillary or interfoliar. In studies of morphogenesis some explanation is needed of the curious fact that whereas leaf primordia are formed, bud primordia are not, although the rudiments of both are histologically identical and both occupy comparable positions *vis-à-vis* the shoot apex. With modifications, the hypotheses of Schoute (1913) afford a means of accounting for the development of a phyllotactic sequence, the inhibition of buds and the regulated or harmonious development of the leafy shoot. The hypotheses now advanced by Prof. Wardlaw are that the shoot apex and each young leaf primordium are a growth-centre around which a physiological field develops; and that a new growth-centre cannot arise within an existing field but can arise on the

apical meristem outside it, that is, fields have inhibitive properties. It is assumed that there is no fundamental metabolic difference between shoot and leaf apices.

These ideas are now supported by a considerable body of experimental evidence which was illustrated in the lecture. Thus it was shown that a leaf primordium, or a primordium site, which is isolated from the adjacent, older primordia by vertical incisions, shows rapid relative growth and soon develops to large size. Reference was made to the work of Mr. and Mrs. Snow, who have shown by experimental means that in flowering plants the next leaf primordium to be formed arises in the 'next available space' on the meristem above the top cycle of primordia. Experimental studies have shown that this also holds good for the ferns. In them, also, the next primordium to be formed arises in the widest available space, yet only occupies a small part of it.

The explanation now advanced is that the space needed for the inception of a primordium must be wide enough so as not to be completely eclipsed by the inhibitive fields of the two adjacent primordia, though the area needed for the actual primordium site may be quite small. In other experiments Prof. Wardlaw showed that the inhibition of buds at the apex is due to the adjacent leaf primordia and that, by appropriate but simple techniques, buds can be induced to arise in what are normally leaf positions and leaves in bud positions. Indeed, it seems that very little is needed to tip the balance between leaf formation and bud formation at the fern apex. The whole of the fern apex is thus totipotent in respect of the formation of its lateral members, and the characteristic symmetry and structure of leaves and buds are due to the positions in which they are formed and to the factors of growth and related factors which are incident in these positions.

Prof. de Beer, referring to the work of Mr. and Mrs. R. Snow and of Prof. Wardlaw on correlation and phyllotaxis, stated how impressed he had been by the many parallelisms between the problems of experimental embryology in plants and animals. He then proceeded to illustrate evidence of the power possessed by certain regions of the animal body to control or suppress the appearance of other structures within a certain distance, citing the control of pharynx development in planarians: the distance of the pharynx behind the head being a function of the degree of development of the head itself. A further example of the power of inhibiting at a distance has been shown by work on the cœlenterate *Cordylophora*. When fragments of this organism are allowed to aggregate, the mass normally gives off a number of outgrowths, each of which regenerates into a polyp. But if to the aggregated mass there is added an oral cone of another individual, not only does the oral cone induce the formation of a polyp immediately beneath itself, but also it inhibits the formation of other outgrowths and polyps.

At this point Prof. de Beer emphasized that these close parallelisms between phenomena in plants and animals would repay further attention. Field phenomena, as exhibited by the apices of plants, can be matched by many examples from animals. In particular, the modification of a leaf position on the meristem by experimental means is closely comparable with data which have been obtained on limb formation in amphibians. Within the limb-disk, at an early stage, there is still an indeterminacy as regards the precise location of the future arm or arms: the only thing that is determined is that if anything is developed at all, it will have the quality of an arm. This state of indeterminacy within an area which already possesses a general determination as regards its fate is usually described by saying that the rudiment represents a morphogenetic field: within that field the power of regulation is still present. The properties of morphogenetic fields were illustrated by reference to Prof. Murray's experiments on the limb-bud of chicks. When the limb-disk has grown out into a conical bud, a regional determination into subfields apparently takes place, for, when isolated, the proximal half, in the case of a leg, develops into a complete and nearly perfect thigh, without any shank, while the distal half of the same bud can give rise to a perfect foot and shank. Within the sub-fields, regulation takes place by means of the formation of the structure characteristic of that sub-field and the suppression of others.

By reference to these and other examples, Prof. de Beer showed how the discoveries already made by experimental embryologists may shed light on some of the problems that are now engaging the attention of botanists interested in morphogenesis.

OBITUARIES

Mr. H. H. Cousins

HERBERT HENRY COUSINS, son of the Rev. W. E. Cousins, was one of the group of young scientific workers who, in the mid-eighteen-nineties, took their courage in their hands and boldly turned over to agriculture, taking advantage of the means provided by Mr. Goschen's tax on whisky, put on in 1890, the proceeds of which might be utilized by a county for advancing agricultural education. The counties of Kent and Surrey early decided to do this, and under the guidance of A. D. Hall in 1894 established an agricultural college at Wye in East Kent. From the outset, Hall took the view that his colleagues must first and foremost be thoroughly expert in the pure science which they professed; he knew that agricultural knowledge could be added at Wye, but nothing could make good any weakness in the scientific foundations. Cousins was appointed chemist. He had had a good career in pure chemistry. He was a postmaster of Merton College, Oxford, and in 1889 he gained a first-class in natural science; he studied later at Heidelberg, then the Mecca of young chemists from Great Britain. He returned to Oxford for a time as demonstrator in the chemical laboratories, and took an active part in the University extension lecture scheme, then very popular.

In 1894 Cousins went to Wye and immediately began studying the practical problems of agriculture and gardening. He took a house with a large garden on Church Green and then began to grow plants, subject always to the criticisms of the very expert village workers, acquiring the full knowledge of this subject that he afterwards set out in a delightful little book, "Chemistry of the Garden". He was obviously much influenced by Georges Ville and Sir William Crookes, and under-estimated the role of organic manures; had he revised the book when he retired and had some leisure, it might still have been a standard treatise. He was also interested in pigeons. In the laboratory he made pioneering studies of hop resins, washes and other practical problems, and he translated into very readable English Kellner's text-

book on animal nutrition, then the leading German treatise on the subject.

Short in stature, but full of courage, outspoken and very deliberate of speech, capable of vaulting over any fence or gate that he could see over, he won the respect of the students but was too reserved to make friends among them. His wife, Minnie, daughter of Mr. R. J. Hardy, and their three children, two daughters, one of whom died in 1926, and a son, made the home an attractive place for those privileged to visit it.

In 1900 Cousins accepted the post of island chemist, Jamaica, where one of his various duties was to overhaul the manufacture of rum. He so impressed the authorities that in 1908 he was appointed director of agriculture, a post which he held until 1932. He had already in 1907 been appointed a member of the Legislative Council and retained his seat until 1923; his profound knowledge of the island and of its possibilities marked him out as the obvious chairman of the commission to inquire into the distressed districts.

Cousins concentrated his attention on the island problems and made little contribution to the various controversies in agricultural science that developed during the first thirty years of this century; his records are found in his official reports and in the Jamaica Herd Book. He never lost his gift of lucid writing, however, as shown by his "History of Hope Farm".

He retired from the directorship in 1932 and in due course settled in Oxford where, through failing health, he lived in quiet retirement, taking no part in the numerous agricultural activities there going on; the younger generation, therefore, had little opportunity of getting to know him. This was a pity, for he was a man of full knowledge and ripe experience of the type of problems now daily assuming more and more importance. E. JOHN RUSSELL

Mr. E. G. Baker

EDMUND GILBERT BAKER died at his home at Kew on December 17, at the age of eighty-five. He was the only son of John Gilbert Baker, the well-known Yorkshire botanist, who in 1866 became first assistant in and later (1890–99) keeper of the Herbarium, Royal Botanic Gardens, Kew. E. G. Baker was born at Thirsk, Yorkshire, on February 9, 1864, and received his education at Bootham School, York, and the Pharmaceutical College, London. For some time after serving an apprenticeship as a pharmacist at Chertsey he remained connected with pharmacy, and was awarded the Pereira Medal by the Pharmaceutical Society in 1886. His interest in botany was, however, already evident, and in 1887 he was appointed to a junior assistantship in the Department of Botany at the British Museum (Natural History). He was elected a fellow of the Linnean Society in the same year and served on the Council during 1917–21. He retired from the staff of the British Museum in 1924, but continued to work in the Department of Botany for many years after his official retirement and was designated honorary assistant keeper.

E. G. Baker was a taxonomist of the old school. He was for a long period in charge of the Polypetalæ at the Museum and was responsible for the working out of the members of this group in many important collections received during the period he was assistant. Papers by him, often in association with colleagues, were published in the *Journal of Botany*, the *Journal of the Linnean Society*, and elsewhere. He wrote an important paper on the African species of *Crotalaria* (*J. Linn. Soc.*, **42**, 241; 1914). When he became independent of official duties he concentrated on African Leguminosæ and published his most important work, "The Leguminosæ of Tropical Africa", in three parts, 953 pages in all (Ghent, 1926; Ostend, 1929; Ostend, 1930). This contains generic descriptions and keys and short descriptions to the species and varieties of members of the family from tropical Africa.

E. G. Baker was closely associated with the Society of Friends and served with one of their ambulance units in the First World War. He was never married and his only sister predeceased him.

W. B. TURRILL

Mrs. Evershed

WE regret to record the death of Mary Acworth Evershed, at her home in Ewhurst on October 25. She was the fifth child of Captain Orr, R.A., and Mrs. Orr, and was born at Plymouth on January 1, 1867. Her father died when she was three years old, and her mother and family then went to live in the vicarage of South Stoke, near Bath, of which parish Mrs. Orr's father was vicar.

Even in her early days she displayed an interest in astronomy—an interest which was destined to ripen in later years into important work in this branch of science. When she was about twenty years old she went abroad, studying Italian and German and also art; afterwards she spent several years in Australia (1889–95). There she met Mr. Tebbutt, of the Observatory of Windsor, N.S.W., from whom she received a considerable amount of encouragement in her astronomical studies, and who wrote a preface to her first work, "Southern Stars".

The year following her return to England in 1895 she joined the British Astronomical Association, and went on the B.A.A. Eclipse Expeditions to Norway in 1896 and to Algiers in 1900. Arrangements were made for her to work at Dunsink Observatory in 1905, when Prof. (now Sir Edmund) Whittaker was at the University of Dublin; but the scheme did not materialize owing to her marriage in 1906 to Mr. John Evershed. When he went to Kodaikanal Observatory, India, she accompanied him, travelling by way of the United States and Japan, and visiting a number of observatories on the journey. During her stay in India she published her work, "Dante and the Early Astronomers", in 1913, and two years later her book "Stars of the Southern Skies" appeared.

Mrs. Evershed did important solar work at the Kodaikanal Observatory and contributed a memoir on prominences and also a paper in the *Monthly Notices of the Royal Astronomical Society* (**73**, 422; 1913). She was elected a fellow of the Society in 1923, serving for a time on the Library Committee, and was also a member of the Astronomical Society of the Pacific. In 1930 she was appointed the first director of the newly formed Historical Section of the British Astronomical Association—a position which she held for fourteen years, and in which she did very valuable work. Members will remember her unfailing courtesy and prompt attention to queries relating to the historical side of astronomy.

NEWS and VIEWS

Institution of Electrical Engineers Awards

THE Council of the Institution of Electrical Engineers has elected Prof. E. W. Marchant to be an honorary member of the Institution in recognition of his services to the Institution and for the outstanding contributions he has made to the advancement of electrical knowledge.

The Faraday Medal of the Institution has been awarded to Sir James Chadwick, for his contributions to science generally and more particularly for his distinguished work in nuclear physics.

Prof. E. W. Marchant

PROF. MARCHANT is a past-president of the Institution and has given long and distinguished service on the Council. He is now emeritus professor of electrical engineering in the University of Liverpool. At an early stage in his career, Prof. Marchant worked with W. Duddell on the development of the bifilar oscillograph and with Lord Blythswood on the absorption of X-rays by aqueous solutions of metallic salts, establishing the dependence of this absorption of the solution on the atomic content. In 1900 he made experimental tests on the oscillatory discharge of condensers, from which the ohmic resistances of spark discharge carrying currents up to 2,000 amp. were estimated. He became senior lecturer under Silvanus Thompson at Finsbury Technical College and in 1901 went to University College, Liverpool. When in 1903 the College achieved university status, Prof. Marchant was appointed to the David Jardine chair of electrical engineering, which he held until his retirement in 1941. He devised equipment for the accurate measurement of the strength of radio signals, and also designed a new high-voltage laboratory for the impulse testing of high-voltage cables which was opened in 1940. Prof. Marchant's long association with the Institution commenced in 1898 when he was elected an associate.

Sir James Chadwick, F.R.S.

SIR JAMES CHADWICK collaborated in the 'twenties with Lord Rutherford in research work at the Cavendish Laboratory; the fundamental researches they then conducted laid the foundations on which the structure of modern nuclear physics rests. In 1935 he went to the University of Liverpool, where he was Lyon Jones professor of physics until 1948, when he returned to Cambridge as master of Caius College (see *Nature*, 161, 964; 1948). For his work in investigating α-, β- and γ-rays, and particularly for his discovery in 1932 of the neutron, Sir James was in that year awarded the Hughes Medal of the Royal Society; this last-named discovery was further recognized in 1935 when he received the Nobel Prize for Physics. His services during the Second World War in connexion with the developments in the use and control of nuclear energy were honoured in America when he was awarded the United States Medal of Merit. He was knighted in 1945.

International Exchange of Students for Technical Experience

THE second annual report of the International Association for the Exchange of Students for Technical Experience (Pp. 28. London: J. Newby, General Secretary, Imperial College of Science and Technology, 1949) covers the period January–October 1949, inclusive. The numbers exchanged increased from 920 in 1948 to 1,236, and of these Great Britain supplied 285, Finland 171, Netherlands 140, Sweden 137, France 132, Denmark 89, Norway 88, Switzerland 80, Austria 68 and Belgium 46. Great Britain received 314 of these students, Sweden 288, France and the Netherlands 123 each, Norway 86, Switzerland 85, Denmark 73, Austria 53, Finland 49 and Belgium 42. During the summer vacation of 1949 the students were distributed in almost every branch of industry, but mechanical (408), electrical (216), chemical (187) and civil engineering (182) claimed by far the greater number, mining (75) and chemistry (44), which came next, being far behind. In some countries the industrial distribution was better balanced, but in others it should be possible to provide a wider range of industrial experience for students of science and technology. In September the Association was approved by the executive board of the United Nations Educational, Scientific and Cultural Organisation for consultative arrangements. The Brussels Treaty Permanent Commission appointed a liaison officer between the Association and its cultural committee, and the exchanges made by the Association were highly praised by the mixed commission under the Cultural Convention between the United Kingdom and Norway at its meeting at Edinburgh in June. Austria participated for the first time in 1949, and it is hoped that Italian students will participate fully in the 1950 exchanges. Details are given in the report of the participating institutions and firms; in Great Britain students from the Universities of Cambridge, Durham, Oxford, Birmingham, Bristol, Edinburgh, Glasgow and London, the Manchester College of Technology and the School of Metalliferous Mining (Cornwall) participated. Reports on work by foreign students visiting Great Britain show a keen appreciation of the facilities provided.

Science and International Relations

THE fifteenth Robert Boyle Lecture delivered by Dr. J. Needham before the Oxford University Scientific Club on June 1, 1948, on "Science and International Relations" (pp. 30. Oxford: Blackwell's Scientific Publications, 1949; 2*s*. 6*d*.), has now been published. Dr. Needham devotes the first part of his lecture to a brief but lucid survey of the international unions and their inter-relations as well as of their relations with Unesco, before proceeding through a survey of international government scientific organisations of the scientific liaison offices, and of the United Nations Organisation and its specialized agencies to outline the origin and structure of Unesco. In the course of this useful survey Dr. Needham notes that the International Bureau of Physico-Chemical Standards is enlarging its work by a grant from Unesco and accumulating samples of chemicals which are rare or unobtainable in commerce. Among new unions in process of formation are the International Union of Nutritional Sciences, the International Union of Ethnology, Pre-History and Anthropology, the International Union for the Preservation of Nature, and possibly an International Union or Council of Agricultural Sciences.

Much of the value of Dr. Needham's lecture lies in the clear picture he gives of these inter-relations, but he concludes with a most opportune survey of the scientific programme and achievements of Unesco in which, emphasizing the necessity in international intercourse for the point of view of the man of science, he pleads for an end to parochialism among

scientific men themselves. They must play their part in the relations of their own country with other countries whether by meetings or travels on scientific business, by means of work in their own foreign services, or in international organisations under the United Nations in which may be brought together scientific workers from every people and every land. Dr. Needham includes in his lecture warm tributes to the work of Dr. Julian Huxley and of Dr. J. T. Bodet, who has succeeded the former as director-general of Unesco.

Technical Co-operation in Africa

REPRESENTATIVES of the Belgian, French, Portuguese, South African, Southern Rhodesian and United Kingdom Governments held a Conference in Paris during January 11–14 to continue the work on technical co-operation in Africa south of the Sahara which has been going on during the past five years. The first in this series of meetings was held in 1945 between the French and British Governments and concerned itself with West Africa, when questions of public health were examined. Since that time technical co-operation has been extended to other subjects and now includes Belgium, Portugal, South Africa and Southern Rhodesia and their dependent territories. Resulting from the Conference just held in Paris, it has been agreed to recommend the establishment of a Commission for Co-operation in Technical Matters in Africa south of the Sahara. This Commission, which will meet twice a year, will have an administrative role and have among its objects that of giving practical effect to technical co-operation in Africa. The Conference also recommended that the existing practice should be maintained whereby observers from the specialized agencies of the United Nations or E.C.A. are invited to be present at its technical conferences. The Conference also agreed to the establishment of a secretariat with its seat in London, which would have the task of: (*a*) reviewing and co-ordinating the programmes of technical co-operation in Africa south of the Sahara, including follow-up action for dealing with rinderpest, sleeping sickness, soil conservation, anti-locust campaigns, etc.; (*b*) drawing up and submitting to the Member Governments plans for further programmes of technical co-operation; (*c*) seeking the approval of governments for recommendations made at recent conferences, such as the transport conference at Lisbon, scientific conference at Johannesburg, nutrition conference at Dchang, French Cameroons, and indigenous rural economy conference at Jos, Nigeria.

A Systemic Insecticide in Commercial Production

ONE of the most striking of recent developments in insecticides has been the discovery in Germany of the toxic properties of a long series of organic phosphorus compounds. Some of these compounds have the property of being absorbed by the roots or leaves of plants and being translocated to other parts, so killing all the aphids and other sucking insects which feed upon them. One of these compounds, *bis* (*bis*-dimethylamino)-phosphonous anhydride (see *Nature*, May 21, 1949, p. 787, and September 24, 1949, p. 522), has been selected by Pest Control, Ltd., of Cambridge, and with remarkable speed has now been developed and made available commercially under the name of 'Pestox 3'. The great virtue claimed for this material is that while it is highly toxic to greenfly and to red spider mites, it is without effect on ladybirds, parasitic Hymenoptera, and other enemies of these pests. There is some disagreement in the published reports upon the extent to which this material is absorbed and translocated after application to the leaves of plants; but there can be no question about its great effectiveness in practical use. The chief problem raised by the widespread use of this systemic insecticide is one of toxicity to man. This will not arise when it is used on roses or chrysanthemums—except that the greatest care is needed on the part of those who have to handle and apply the insecticide. But where it is used on crops for human consumption, it is highly dangerous to apply it later than one month to six weeks before marketing. This places a heavy responsibility on the grower.

New Insect-proof Material for Packaging

A NEW insect-proof packaging material which is cheap and very easy to handle has been developed by the Pest Infestation Laboratory of the Department of Scientific and Industrial Research. There is considerable wastage in packaged foods, resulting from the penetration of insects from outside. It was found that a layer of sand-paper formed an effective barrier, but did not prove practicable in use. Paper and corrugated cardboard impregnated with D.D.T. were unsuccessful because the insects bored straight through and so did not remain long enough in contact with the insecticide to pick up a lethal dose. The final solution was to use cellulose wadding, several layers thick, impregnated with D.D.T. When faced with this material the insect, after getting through the first layer, wanders in all directions and so takes up enough D.D.T. to be killed. Not one insect has ever got through this material in the course of numerous laboratory tests. The material is bulky and therefore suited to covering groups of packages rather than small containers. Provided there is a fairly large overlap, the wadding need not be sealed round the package; it will be sandwiched between layers of ordinary paper to prevent contamination of the goods by D.D.T. This packing material is due for testing on a commercial scale shortly.

Northern Advisory Council for Further Education

IN the second year of its existence the Northern Advisory Council for Further Education had before it the dual task of building up its organisation and of carrying out the advisory duties laid upon it during its year of inauguration. An interlocking regional plan for technical, commercial and art education has been produced and issued to local education authorities in the area for information and guidance in preparing their own development schemes. Surveys have also been made of the educational requirements of a number of industries, and a regional scheme formulated for courses of training for part-time and intending part-time teachers. Contact with the industry of the region has been broadened by the establishment of permanent advisory committees for the important building and engineering industries. Copies of this interesting report showing how technical education is being integrated on a regional level may be obtained from the Secretary, 43 Eldon Place, Barrasbridge, Newcastle upon Tyne, 1.

Earthquakes Registered in New Zealand

DURING the second quarter of 1949, thirty-eight strong and thirty-eight minor shocks were regis-

tered on the seismographs in New Zealand. Of these, at least ten of the strong shocks and all the minor ones were local. The greatest of these local shocks had instrumental magnitude 6¼ and was felt with intensity 6 on the Modified Mercalli scale in the southern part of South Island. It occurred on May 27 at 8h. 54·1m., G.M.T., and the epicentre was near lat. 45·5° S., long. 167° E. Three local earthquakes also attained instrumental magnitude 5¼. These were on April 9 (epicentre 36½° S., 178° W.), May 29 (epicentre 39·7° S., 174·2° E.) and June 27 (epicentre 37·55° S., 177·05° E.).

Smith–Mundt Grants for Study in the United States

UNDER Public Law No. 402, Eightieth Congress (Smith–Mundt Act), a limited number of dollar grants from the United States Government are available to university teaching staff or those of equivalent academic status in other institutions and to senior research workers who wish to visit the United States for the purpose of study, research or lecturing. Candidates must be affiliated with an American institution of higher learning; research workers must spend at least three months in the United States, and visiting lecturers at least six months or one semester; all applicants must be citizens of the United Kingdom. Successful candidates will also be awarded a Fulbright grant to cover travel from Great Britain to the United States and return. The maximum grant under the Smith–Mundt Act is 2,000 dollars a year, plus the cost of internal travel within the United States (when not covered by the Fulbright grant), plus an allowance of 10 dollars a day during this travel. The grants will operate for twelve months from June 1. Prospective candidates should write immediately to the United States Educational Commission in the United Kingdom, 55 Upper Brook Street, London, W.1, for the application forms, which must be returned before February 18.

Scientific Film Shows at the Science Museum

IN order to familiarize a wider public with the increasing use of scientific films, both as a means of research itself and as a means of disseminating scientific information, special film shows will be held on the third Saturday of every month in the lecture theatre of the Science Museum at South Kensington. These shows have been arranged by the Scientific Film Association and will take place at 10.45 a.m. Admission is free. At the opening meeting, on January 21, two films will be shown: "Ermites du Ciel", a French film describing the life, conditions and equipment at the Pic du Midi Observatory in the Pyrenees, and "Heating Research in Houses", produced by the Building Research Station.

Third World Petroleum Congress

THE Third World Petroleum Congress will be held at The Hague, Holland, during May 28–June 6, 1951. The main headings under which papers will be presented and discussed are: (1) geology and geophysics; (2) drilling and production; (3) refining technology—(*a*) physico-chemical methods, (*b*) methods involving change in composition; (4) petrochemicals; (5) analysis and testing; (6) utilization of products; (7) plant and equipment; (8) transport, storage and distribution; (9) economics and statistics. The various sessions will be held in hotels in The Hague, and the information office will open in the Kurhaus Hotel on May 28, 1951. Excursions to petroleum and industrial centres and to places of interest will be arranged, and social events for the evenings will be organised. The Permanent Council of the World Petroleum Congress has requested the appropriate body in each country to form a national committee which will be responsible for organising the collection of papers within its own country. For Great Britain, the Institute of Petroleum has been invited to form the national committee, and this consists of: E. A. Evans, Lieut.-Colonel S. J. M. Auld, C. Chilvers, T. Dewhurst, Prof. F. H. Garner, H. S. Gibson, H. Hyams, G. Sell, C. A. P. Southwell, H. C. Tett. Further details can be obtained from the Secretary of the Third World Petroleum Congress, Carel Van Bylandtlaan 30, Den Haag, Holland.

"Low-Frequency Components of Atmospheric Pulses and their Origin"

REFERRING to the communication by Prof. S. R. Khastgir and R. Roy in *Nature* of September 17, p. 488, under this title, Mr. C. E. R. Bruce, of the Electrical Research Association, 5 Wadsworth Road, Greenford, Middlesex, points out that he gave a similar and quantitative explanation of the effect in *Nature*, **148**, 165 (1941). This communication had been overlooked by Prof. Khastgir.

Announcements

PROF. N. E. ODELL, of the Department of Geology and Geography, University of British Columbia, has been appointed professor of geology in the University of Otago, Dunedin, New Zealand.

DR. F. D. RICHARDSON, head of the Chemistry Department of the British Iron and Steel Research Association, has been appointed Nuffield Research Fellow in extraction metallurgy at the Royal School of Mines, London. The purpose of this new fellowship is to permit the establishment of an academic research group to work on the extraction metallurgy of both ferrous and non-ferrous metals. Within this field, Dr. Richardson intends that the researches of his team should be devoted to the thermodynamics of slag and metal solutions of importance in extractive processes.

THE twenty-fifth anniversary of the granting to the Textile Institute of its Royal Charter and the fortieth anniversary of the foundation of the Institute on April 22, 1910, will be marked by a dinner to be held at Bradford on March 14.

A SYMPOSIUM on molecular structure and spectroscopy will be held at the Mendenhall Laboratory of Physics at the Ohio State University during June 12–17. Further information can be obtained from Prof. Harald H. Nielsen, Mendenhall Laboratory of Physics, Ohio State University, Columbus 10, Ohio.

AT the invitation of the Swedish National Committee for Crystallography, the Second General Assembly and International Congress of the International Union of Crystallography will be held in Stockholm during June 27–July 3, 1951. These dates have been chosen in consultation with the Swedish National Committee and with the National Committees of all the countries adhering to the Union, and it is hoped that this early notice will make it possible for crystallographers throughout the world to arrange to attend. Further particulars of the meeting will be available in due course.

TUBERCULOSIS

By JOHN FRANCIS
Bramhall, Cheshire

TUBERCULOSIS is the most important cause of death in Great Britain[1], and is rapidly becoming one of the most important diseases in the tropics. There are about four hundred deaths from tuberculosis every week in England and Wales, which is about twice as many as all other deaths classified by the Registrar General as due to "infective and parasitic" diseases.

To the bacteriologist interested in veterinary or human medicine there are many reasons why the *Mycobacteria* should form the most interesting group of organisms. Their 'acid fastness' distinguishes them from all the other bacteria. Within this one group a greater range of parasitism is displayed than in all other bacteria; from free-living forms such as *Myco. phlei*, which grow on simple media, one passes by stages of increasing difficulty of cultivation to the avian, human and bovine tubercle bacilli. It is of interest to note, however, that although the tubercle bacilli are difficult to isolate, and grow slowly, they were among the first pathogenic bacteria to be grown in synthetic media. *Myco. johnei*, the cause of a chronic enteritis in cattle (Johne's disease), was not cultivated until Twort and Ingram[2] showed that the addition of an extract of other acid-fast bacteria permitted growth. This was in the very early days of the work on vitamins, yet much of their monograph might have been written to-day. The growth factor has only recently been isolated in a state of purity by Francis *et al.*[3]. Finally, we have the leprosy bacillus, which, although one of the first bacteria to be associated with disease in man, when it was observed by Hansen in 1874, remains the only important pathogen that has not been cultivated. In addition, there is the whole question of the relationship of the three types of tubercle bacilli, which should be of interest to all those interested in the genetics of bacteria: the evidence that change of type does occur will be presented by Francis[4]. Again, the pathogenesis of the various forms of tuberculosis and the behaviour of the different types of bacilli in various species represent one of the most interesting fields in comparative pathology[5,6,7].

In view of the foregoing facts, one would imagine that the *Mycobacteria* and the diseases they produce would stimulate a great deal of scientific interest and research. It is true that tuberculosis attracted great public and scientific interest from 1882, when Koch discovered the tubercle bacillus, until about 1915. This period culminated in Great Britain with the publication of the reports of the Royal Commission on Tuberculosis. Since then a great deal of routine work has been done; but it would appear that, with a few notable exceptions, scientific workers in Great Britain have not considered that tuberculosis offers a very attractive field of research. Great effort is expended on the study of every aspect of malignant disease. The chemotherapy of virus infection attracts much interest, and even the common cold is the object of special research effort; but it would appear that nowhere in Great Britain is any similar effort being expended on the study of the agent which is the most important cause of death in Great Britain. It should be pointed out that tuberculosis is much more susceptible to a properly devised scientific attack than many conditions which receive so much more attention: it is, in fact, the last of the great zymotic diseases in civilized communities and is susceptible to the same methods of control (properly modified) as other similar epidemics. This has been amply proved, if proof is necessary, by the virtual eradication of bovine tuberculosis from Finland, the United States, Norway, Sweden and Denmark, and the rapid progress of the Attested Herds Scheme in Great Britain.

There are now 1½ million out of about 9 million cattle in attested herds in Britain, and the Minister of Agriculture announced on November 10 that area eradication would begin in October 1950. There is good reason to believe that the eradication of tuberculosis will make a considerable contribution to the efficiency of milk production, and by lengthening the life of dairy cows and reducing the need for replacements, will permit better selection for milk-yield and other qualities.

The tuberculin test forms the basis of the Attested Herds Scheme in Great Britain, and the whole subject of tuberculin-testing has been intensively studied for many years. Siebert developed P.P.D. (purified protein derivative) tuberculin in 1934, and large quantities of tuberculin protein are produced at the Ministry of Agriculture's Veterinary Laboratory for the 'comparative intradermal' tuberculin test which is used in Great Britain[8]. The great merit of P.P.D. tuberculin is that it can be standardized to ± 0·5 per cent by chemical methods, although concurrent biological tests are always carried out. On the other hand, 'Old Tuberculin' can only be standardized to ± 50 per cent unless large groups of guinea pigs are used. P.P.D. tuberculins do not appear to have been widely adopted for human use in Great Britain. The reasons for this may be that the limitations of the tuberculin test and the importance of careful standardization are less evident in man than cattle, because people are subjected to post-mortem examination immediately after testing much less often than cattle.

There has been so much public controversy about pasteurization that the importance of tuberculous infection from milk has become greatly overestimated, and many members of the general public believe that if milk is freed from tubercle bacilli there will be a rapid decline in human tuberculosis. In fact, the freeing of milk from tubercle bacilli will at best do very little to reduce the incidence of human tuberculosis. Alimentary infection acquired by drinking tuberculous milk is usually mild, and there is good evidence that such infections acquired during childhood protect from pulmonary tuberculosis in adolescence. There is, in fact, an inverse relationship between the incidence of tuberculosis in cattle in country districts and the mortality from human tuberculosis in these districts[9]. All this does not mean that we should fail to make milk safe: it does mean that greater efforts should be made to protect from the more dangerous human infection, and increase resistance by the use of B.C.G.

Most of the extensive work done on tuberculosis in man has been devoted to devising better means of treating the clinically tuberculous; even the danger to medical men and nurses which these patients represent has often been overlooked, and the study of the methods of using and standardizing B.C.G.

vaccine for use in man has been almost completely neglected in Great Britain[10]. This vaccine is prepared from an attenuated strain of the bovine tubercle bacillus isolated from cow's milk by Nocard (one of the pioneer veterinary scientists, who was an authority on tuberculosis), and attenuated by Calmette and Guèrin, between 1910 and 1920, at the Pasteur Institute. Its possible use in the veterinary field has been fully studied in Great Britain; but although it produces a considerable immunity in cattle, the need for vaccination is much less than in man, because animals can be much more easily controlled and radical methods of eradication applied.

During the past few years, there has been a growing interest in tuberculosis, and this has been reflected in the activities of the Tuberculosis Association and the National Association for the Prevention of Tuberculosis. A tuberculin-testing survey is being carried out, and this will form an essential prelude to the extended use of B.C.G. which it is hoped will be rapidly introduced.

The National Association for the Prevention of Tuberculosis was founded in 1896: the second Commonwealth and Empire Health and Tuberculosis Conference*—the first was held two years ago—celebrated the fiftieth anniversary of an organisation which has done much to create public interest and stimulate official action in the problems of tuberculosis, not only in Britain but also throughout the Commonwealth. It is perhaps a natural consequence of human nature, which is essentially improvident, that the greatest interest centred on the papers of Dr. Geoffrey Marshall, Prof. Etienne Bernard, Prof. Jörgen Lehman and Mr. C. Price Thomas, dealing with the chemotherapeutic and surgical treatment of tuberculosis. The meeting was, however, privileged to hear papers from Dr. K. A. Jensen and Prof. Arvid Wallgren on the use of B.C.G. There is now good reason to believe that B.C.G. vaccination will reduce both the morbidity and mortality in exposed groups by 60–80 per cent. It is clearly not possible to isolate everyone in Great Britain suffering from tuberculosis; but a reasonable amount of effort would make it possible to vaccinate persons most heavily exposed to infection. Dr. Wallgren stated that he had not seen miliary tuberculosis or tuberculous meningitis in any child properly vaccinated with B.C.G. In France and the Scandinavian countries, no tuberculin-negative nurse is allowed to enter a tuberculous ward until she has been satisfactorily vaccinated with B.C.G.

In an outstanding paper, Dr. Marc Daniels summed up a discussion on the danger of infection to nurses and students, and attempted to dispel some of the illusions which exist about tuberculosis: "For some reason which I shall never grasp, tuberculosis is singled out as a disease of which people will calmly talk of small occasional infections as a useful method of immunization—a most costly method, since it produces in the general population many thousands of deaths a year. Immunization by uncontrolled infection, for a disease which is often fatal, is an absurdity. It is presumably on the principle that a little tuberculous infection is not a dangerous thing, that one sees in tuberculosis nursing in many hospitals throughout the country a lack of elementary precautions which would be regarded with horror in any ward of other contagious diseases or any maternity or surgical ward. I need only quote, for instance, the lack of instructions to new nursing or domestic recruits attending tuberculous patients for the first time. When I refer to these things, I am referring not to what is the practice in some of our best hospitals, but to what is the practice in a high proportion of other hospitals."

The situation in a country where tuberculosis is receding was illustrated by Dr. C. J. Beckwith, chairman of the Executive Committee of the Canadian Tuberculosis Association. He stated that since the tuberculin test is now positive in only some 20 per cent of Canadians under the age of twenty—indicating a great reduction of infection since the early years of the century—this test is now much more valuable than it was. He advocated the use of B.C.G. for students and nurses, and remarked that the main emphasis in tuberculosis work in Canada had been on the clinical side: epidemiological work had been somewhat neglected.

A very different aspect of the subject was presented by Dr. J. B. McDougall, secretary of the World Health Organisation Expert Committee on Tuberculosis. He stated that there are two to five million deaths a year from tuberculosis. He referred to the importance of the conclusion by the Food and Agriculture Organisation that adequate nutrition is the most important issue now facing the world, and that in many countries methods of food production need to be changed completely. Dr. Ram Chandra Adhikari, of the Bengal Tuberculosis Association, said that in India the incidence of tuberculosis is rapidly mounting; but its true extent is not known. The average income per head of the population is falling; and since the beginning of the century the population has increased by more than 100 million. Industrialization is proceeding apace, with a great movement from villages to the slum areas of towns; the status of some slums has deteriorated during and since the Second World War. Only 7,000 beds are available, whereas at least 500,000 are required. Dr. P. V. Benjamin described the plans for using B.C.G. in India; it is hoped to vaccinate 80–100 thousand people during the next five years.

These last papers served to direct attention to a much wider and more important subject than that of tuberculosis, but one which was, as usual, not discussed—the relationship of population to food supply. As pointed out by Malthus, population has a natural tendency to increase by a geometric progression, whereas, at best, food production only increases by an arithmetic progression. Only two alternatives are open to mankind: population can be kept in check by "disease, starvation and war", or by the much more humane method of preventing conception. No amount of argument, improvement in agriculture, land reform or change of political systems can in the long run enable mankind to avoid these alternatives, yet this whole subject is very largely ignored by politicians and scientific workers alike.

In his presidential address to the Newcastle meeting of the British Association, Sir John Russell did just refer to the need for "Western restraints" if Western standards of living are desired, and it is encouraging that the subject has been frankly discussed by *The Lancet*. It is pointed out in a leading article[11] that medical men can no longer ignore the cumulative effects of preventive medicine, or the fact that every day 50,000 more people sit down to the world's breakfast: "if it is now within our power to

* The full proceedings of this Congress, which was held in London during July 1939, have been published by the National Association for the Prevention of Tuberculosis, Tavistock House N., Tavistock Square, London, W.C.1.

reduce death rates it is also within our power to limit birth rates". It quotes Vogt[12], who believes that wherever the Food and Agriculture Organisation finds over-population, its conservation and food production programmes should include contraception programmes. He believes that food production may decrease rather than increase in many areas, and points out that, much more than is generally realized, the achievement of the 'four freedoms' depends on a fifth freedom: freedom from excessive numbers of children. Returning to the problem of tuberculosis in India, it is obvious that efforts will continue to be made to reduce the number of deaths from tuberculosis; but it is difficult to see what real benefit this will produce in a country the population of which is increasing faster than its ability to produce or purchase food. In such circumstances the agricultural and veterinary sciences are of prime importance, and control of disease in man can only be of real benefit if it is combined with efforts to reduce the birth-rate: it is difficult to see what benefit is conferred by preventing ten thousand people from dying of tuberculosis this year in order that, in five years time, they may die of starvation.

[1] Stocks, P., *Tubercle*, **30**, 50 (1949).
[2] Twort, F. W., and Ingram, G. L., "Johne's Disease" (London, 1913).
[3] Francis, J., Madinaveitia, J., Macturk, H. M., and Snow, G. A., *Nature*, **163**, 365 (1949).
[4] Francis, J. (to be published).
[5] Rich, A. R., "The Pathogenesis of Tuberculosis" (Baltimore, 1944).
[6] Francis, J., "Bovine Tuberculosis, including a Contrast with Human Tuberculosis" (London, 1947).
[7] Pagel, W., in Kayne, Pagel and O'Shaughnessy's "Pulmonary Tuberculosis" (Oxford, 1948).
[8] Green, H. H., *Vet. J.*, **102**, 267 (1946).
[9] Francis, J., "Control of Infection with the Bovine Tubercle Bacillus", *Lancet*, i, Jan. 6 (1950).
[10] Francis, J., "Tuberculosis: the Control of an Infectious Disease", *Lancet*, ii, 549 (1949).
[11] Editorial, *Lancet*, ii, 613 (1949).
[12] Vogt, W., "Road to Survival", 335 (London, 1949).

CONFERENCE OF HOME UNIVERSITIES

THE fourth post-war Conference of the Universities of Great Britain and Northern Ireland was held at the Senate House, University of London, during December 16–17, and was attended by about a hundred delegates and guests.

At the first session, Sir Walter Moberly spoke on his book "The Crisis in the University" in the light of comments that have been made, particularly by Mr. Michael Oakeshott in the *Cambridge Journal*, and by a number of contributors in the November issue of the *Universities Quarterly*. Sir Walter emphasized that although his book was written with a Christian outlook, it is imperative from every point of view that the aims of the universities should be redefined, and values re-considered. There are also, he said, a number of practical problems requiring decision, such as the communal relations of staff and students and the length of courses; but paramount is the need to ensure that students acquire at the university a philosophy of life and a certainty about ultimate loyalties. He did not, however, want any forced or unreal unity.

Sir Walter was criticized by a number of speakers, who did not share his Christian convictions or accept his disclaimer of any desire to use the universities for the exclusive inculcation of Christianity. Prof. L. J. Russell (Birmingham) thought that the situation had been over-intellectualized, and that the decay of beliefs is due to the breakdown of the social institutions on which they rested. Many of the functions previously performed by the Church and also by the family have passed to other institutions. The associated beliefs have naturally been affected. What is required is a gradual building up of new beliefs firmly based on reality. He strongly supported Sir Walter's concept of the university as an open forum.

Prof. J. F. Kendall (Edinburgh) asked the Conference to compare the Catholic universities of Belgium with the free universities, in which no attempt is made to teach a philosophy of life. Prof. W. M. Calder (Edinburgh) considered that more important than a 'philosophy of life' is 'integrity of intellect'. Mr. Kenneth Urwin (Wales) was concerned with the ultimate results of Sir Walter's prescription, which he thought would be religious tests. Prof. T. M. Knox (St. Andrews) thought that Sir Walter wanted the universities to teach Christianity to those with whom Christian churches have failed. In his opinion, the universities should aim at turning out students who are incapable of not thinking for themselves. Speakers in support of Sir Walter tended to stress the danger of a vacuum. Sir John Maud (Permanent Secretary, Ministry of Education), who was a guest of the Conference, thought that the university should make the student hungry for a 'philosophy of life', but should not teach him any particular one. Prof. D. M. MacKinnon (Aberdeen) urged the necessity of studying the conditions favourable to the open mind and to objectivity. Intellectual honesty is essential if the universities are to survive. The danger of Marxism was emphasized by many speakers; since no voice was raised in its support, the Conference failed to achieve in this respect the open forum advocated by Sir Walter.

At the second session, "The General Education of Students" was the subject, and Prof. F. T. H. Fletcher (Liverpool), speaking as a representative of the Association of University Teachers, gave the opening address. This, he explained, was not a statement of official policy, although the Association of University Teachers has for long been interested in this problem, which is now being generally recognized as the dangers of specialization become more and more apparent. General education, that is, education outside the student's main study, is necessary for three reasons: to increase the value of the student to the community, to increase his effectiveness in his own specialization, and to liberate and enrich the human spirit.

Prof. Fletcher believed that the humanities have more to contribute to general education than the pure sciences and technologies, but Sir Lawrence Bragg (Cambridge) held that the education of the arts student in scientific method and in an elementary knowledge of science is the more urgent part of the problem. The science student is acquainted with the humanities by his previous education; the arts student usually knows little about science.

Prof. H. Hale Bellot (London) considered that the problem centres on the general education of the professor, and instanced as the correct approach to a solution the growing awareness by historians of other fields such as economics. Details of some interesting experiments in general education were given by a number of speakers, and a plea was made by Lord Chorley (Association of University Teachers)

for the publication of this information. Lord Lindsay of Birker explained that the new University College of North Staffordshire is being established as an attempt to overcome the evils of specialization. He had been aware for many years that science and arts students were talking different languages and believed that the position is getting worse. At the new College, the four-year honours course which they would provide would begin with a first year in which general education and the correction of school over-specialization would be prominent.

The third session was concerned with "The Place of Technological Education in University Studies", and opened with an address by Sir Lawrence Bragg (Cambridge) and a paper (read in his absence) by Sir Edward Appleton (Edinburgh).

Sir Lawrence supported the founding of separate institutes of technology, on the lines of the Massachusetts Institute of Technology, but emphasized that he did not want to see all technological studies removed from the universities. Such institutes should be as autonomous as universities, should award their own degrees, and should differ from universities only in outlook. His attempt to draw a line between technological and pure scientific research was criticized by a number of speakers, notably Prof. J. B. Speakman (Leeds), who pointed out that his own university had grown from the Department of Textiles.

Sir Lawrence further maintained that while Great Britain has no need to fear comparison with any other in pure science, its record in technology is less satisfactory.

Sir Edward Appleton affirmed that the aim of the university is to produce engineering scientists, and of the technical college to produce engineers. He would support the establishment of one institute of technology, but was more concerned with the improvement of the existing university provision. He regretted the presence in universities of specialized technologies, and instanced glass, rubber, brewing and textiles.

Prof. Andrew Robertson (Bristol) thought that technological institutes such as the Massachusetts Institute of Technology are too little concerned with fundamental principles, and stated that there is criticism in America on this score. Prof. A. F. Burstall (Durham) supported the establishment of an institute of technology, but Sir John Hobhouse (Liverpool) and Prof. J. F. Baker (Cambridge) were in opposition, the latter declaring that it is the national attitude towards technology in the United States that has most to do with the American success in this field. Prof. J. P. Kendall (Edinburgh) thought that the virtue of the Massachusetts Institute of Technology lies in its lavish equipment and in the excellence of its postgraduate instruction. He was also inclined to oppose Sir Lawrence's proposition. In his opinion the fault in Great Britain lies in the arrangement of school education on the assumption that all the pupils would go to the university. Dr. P. Dunsheath (London) was among those who considered that it would be a mistake to remove technological studies from the university, and Sir Roderic Hill (London), by a statement of the actual proportions, rebutted the contention that technological students are in danger of swamping the universities. Principal J. C. Jones (director of education, Regent Street Polytechnic), a guest of the Conference, stressed the harmful effects of the social prestige of the university degree on the provision of courses by technical colleges, and in his reply to the discussion Sir Lawrence Bragg re-emphasized his desire to see new technological institutions, which would give their own degrees.

At the first session the chair was taken by Prof. Lillian Penson, vice-chancellor of the University of London, at the second by Prof. G. C. Field, pro-vice-chancellor of the University of Bristol, and at the third by Sir Hector Hetherington, principal of the University of Glasgow, and chairman of the Committee of Vice-Chancellors and Principals, which convened the Conference.

VOYAGE OF THE ROYAL RESEARCH SHIP *WILLIAM SCORESBY*

THE Royal Research Ship *William Scoresby* sailed on January 11 on a new voyage of ocean research in continuation of the work undertaken by the former Discovery Committee before the War. She will visit South African waters first, and then make observations across the Indian Ocean. The final months of the commission will be spent in studying whales in the West Australian region.

During the past twenty-five years the Discovery Committee has worked under the Colonial Office, and organised a series of expeditions for scientific research, mainly in the Southern Ocean and Antarctic seas, but sometimes also in subtropical and tropical waters. The work is generally referred to as the "Discovery Investigations", and has been concerned principally with deep-sea oceanography and especially with research on whales. The name "Discovery" was adopted because the work at sea began with Captain Scott's old ship, the *Discovery* (now lying off the Thames Embankment), but most of the investigations have been carried out with the Royal Research Ships *Discovery II* and *William Scoresby*. Since 1939 the ships have been on charter to the Ministry of Transport, but in 1949 the Discovery Investigations, together with the ships and scientific staff, were transferred to the Admiralty and now form part of the National Institute of Oceanography, of which Dr. G. E. R. Deacon is director.

The Institute as a whole covers a wider field, but in the next two years both ships will be engaged in the continuation of the Discovery Committee's programme under the general direction of Dr. N. A. Mackintosh, formerly director of research to the Committee. The *Discovery II*, which is the larger ship, is at present refitting for ocean research; her work will be largely in the Antarctic.

The present voyage of the *William Scoresby* is expected to last about ten months. She is a ship of 324 tons (gross) and has some of the features of a trawler and some of a whale catcher. She carries a commercial otter trawl, and there are deck engines and reels with some thousands of fathoms of wire for deep-sea oceanographical work. The equipment also provides for echo sounding. The latest 'world span' wireless apparatus is in part a gift from the Marconi Co. towards the work of the ship. Dr. T. J. Hart will be in charge of the work at sea until the ship reaches Cape Town. With him will be Mr. R. Clarke (who will take over on leaving the Cape), and Mr. R. I. Currie; Lieutenant-Commander A. F. MacFie will be in executive command.

The most important work to be done on the present cruise is to mark whales off the north-west coast of Australia in the southern winter (July and August). First, however, the ship will make a preliminary survey of the Benguela Current off the coast of South-West Africa, which is a region of interest because cold water from the ocean depths wells up like a spring to the surface. The *William Scoresby* formerly surveyed a similar region off the west coast of South America, where the deep water brings certain nutrient salts to the surface, and causes a rich development of the marine fauna and flora.

She will call at Cape Town, East London and Mauritius, and during the voyage will undertake various oceanographical work both in shallow water, and where the bottom slopes down to oceanic depths. Little is known of the water masses and currents of the central Indian Ocean, and during the passage from Mauritius to Fremantle it is expected that valuable observations can be made. If time permits, some trawling may be carried out in Australian waters, and then about two months will be spent off the north-west of Australia. Before the War the *William Scoresby* marked some thousands of whales in the Antarctic, but this was done in the summer months; it is now necessary to mark them in the winter when they migrate towards the equator. At this time of year an important species, the humpback whale, is known to congregate near the north-west Australian coast.

AGAR FROM BRITISH SEAWEEDS

A WELL-ILLUSTRATED account has been published* of the manifold investigations which led to the exploitation of the available supplies of the British seaweeds *Gigartina stellata* Batt. and *Chondrus crispus* (L.) Stackh. as a source of agar. The book is of value in many different directions. Quite apart from the economic importance of the achievement, these researches afford much information on the growth and seasonal development of these seaweeds, and especially of *Gigartina*. They thus provide one of the most important contributions to the autecology of a red seaweed that has so far been published. Moreover, the very extensive explorations which were necessary and which are a testimony to the immensity of the effort involved have afforded much information of general ecological interest with reference to the marine flora, particularly that inhabiting the shores of the Scottish Isles. The various botanists who co-operated in these researches, and particularly Prof. L. Newton, who played an important part, are heartily to be congratulated on the result. It is to be regretted that work of such marked scientific importance can only be achieved when war-time exigencies demand it.

Up to 1939 most of the agar used in Great Britain and other countries was imported from Japan. Even before the Japanese became belligerents, the need to find substitutes became urgent, so that the comprehensive investigations described in this memoir were initiated already early in the War. Of the various red seaweeds that seemed likely to provide a suitable agar, only the two already mentioned can be gathered in sufficiently large quantities, and *Gigartina* is far more abundant than the almost equally suitable and better-known *Chondrus*. It is therefore not surprising that the greater part of the memoir concerns itself with the former. Except for parts of Northumberland, extensive growths of *Gigartina stellata* are met with only on the west coast, the richest localities being those of the Clyde sea-area, where yields of 8–30 lb. per yard of coast were obtained. This seaweed favours rather gently sloping rock surfaces on exposed or semi-exposed coasts and occurs usually at the base of the *Fucus serratus* zone, either as separate tufts or as an almost continuous belt, sometimes as much as twenty yards wide; it is frequently associated with *Himanthalia lorea*.

Little new information on the life-cycle of *Gigartina stellata* is provided. The occurrence of fertilization remains as doubtful as ever, and even these intensive investigations have not brought to light any tetrasporangiate plants. On the other hand, the detailed studies of seasonal development, that had to be undertaken to determine the best methods of harvesting, have added considerably to our knowledge of *Gigartina*. Although in some districts it behaves as an annual, the plants commonly last for three or four years, the new growth in spring arising either from persisting parts of old erect fronds or often in large part from the conspicuous attaching disk. This increases in thickness with the years and exhibits a number of layers, one probably corresponding to each year of growth. Much the same is true of *Chondrus*, where, however, the holdfast is less firmly attached. The growth of the erect fronds terminates between July and September, and soon after this the gel-strength is at a maximum, while the period of maximum carpospore-discharge lasts from September until December.

These observations indicated that, during harvesting, care must be taken not to destroy or remove the holdfast, so that hand-picking rather than shearing was recommended. Furthermore, it was concluded that a single yearly harvest between July and September would be most appropriate, when a maximum yield would be obtained and there would be no interference with the discharge of spores from remaining plants. It is of interest that these conclusions can be correlated with the past experience of some of the crofters on the Scottish Isles who "are aware that the maximum growth has developed by August and September, that the extract is at its best, that the dried weed keeps better and that it is most easily torn from the holdfast at that time".

The extraction was carried out by boiling in lime water and removing the residue. The cooled extract sets to a weak gel. Various methods of hardening the latter were tested, but the one finally adopted was to heat the extract with potassium hydroxide and neutralize with hydrochloric acid; the amount of the former should not exceed 15 per cent of the dry weight of the extract. Best results were obtained by carrying out the potassium hydroxide treatment in an autoclave for eight hours at 20 lb. per sq. in. or for two hours at 40 lb. per sq. in. The resulting agar has a deep yellow colour which can be removed by treatment with activated charcoal. It has a lower melting point, dissolves much more readily and is denser when set than the Japanese product. It contains a much greater percentage of inorganic material; however, this is not an impurity but forms part of the gel complex.

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* A Study of certain British Seaweeds and their Utilization in the Preparation of Agar. By S. M. Marshall, L. Newton and A. P. Orr; with the collaboration of P. W. Carter, E. Conway, K. M. Drew, E. A. Lewis, J. Macnaughtan, H. T. Powell and others. Edited by L. Newton. Pp. viii+184 (12 plates). (London: H.M. Stationery Office, 1949.) 27s. 6d. net.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Electron Microscope Studies of Normal and Malignant Tissues of High- and Low-Breast-Cancer Strains of Mice

THE consistent finding, by means of the electron microscope, of roughly spherical particles of various sizes but mostly of the order of 200–300 A. in diameter in extracts of tumours, lactating breast tissues, and other tissues of high-breast-cancer-strain mice and their absence in low-breast-cancer strains was reported in *Nature* two years ago[1]; and shortly afterwards[2] it was reported that similar particles were to be found in extracts of milk of the *C3H* high-cancer strain. In the latter communication, it was further shown that it was possible by ultra-centrifugation of tumour extracts to obtain a supernatant apparently free from particles, and it was also reported that the test hybrid mice inoculated with particle-containing extracts described in the first communication had developed mammary tumours, indicating that such extracts were biologically active.

The present position as regards mice injected with extracts tested in the electron microscope prior to our centrifugation experiments is summarized in the accompanying table.

SUSCEPTIBLE HYBRID MICE INJECTED WITH EXTRACTS TESTED IN THE ELECTRON MICROSCOPE

	Extracts with particles present	Extracts with particles absent
No. of mice still alive at the earliest tumour appearance	221	185
No. of tumours	71	7
Average tumour age (mths.)	14·4	18·2
Average age of mice which died free from tumours (mths.)	18·2	15·7
No. of mice still alive	30	36

As regards our earlier centrifugation experiments, the present position is that 13 mice out of 45 injected with sediment have so far developed tumours, while 3 out of 40 injected with supernatant have tumours; but this supernatant (after centrifugation for 1 hr. at 113,000 *g*) still contained a number of particles. In our later centrifugation experiments, however, tumours have developed in mice injected with sediments or with supernatants still containing particles, but no tumours, to date, have appeared in mice injected with supernatants apparently free from particles. It seems, therefore, almost conclusive now that the particles described by us do indeed represent the tumour-inducing agent.

A recent article by Graff *et al.*[3], entitled "Isolation of Mouse Mammary Carcinoma Virus", describes particles obtained directly from the milk of the Paris *RIII* strain of mice in which mammary carcinoma is frequent; but makes no mention of our published findings. Their electron micrographs are similar to some of our earlier pictures which we discarded as being unlikely to be a true representation of the tumour-inducing agent; for it was only after fat extraction (either by treating the desiccated tissues with petroleum ether in the cold or by means of a micro-Soxhlet apparatus with petroleum ether boiling below 40° [4]) and treatment with trypsin that our present satisfactory photographs were obtained. In these the particles (still active) are so sharply defined that it is clear that much, if not all, of the apparent variation in size is due to aggregation, and often symmetrical aggregation, of smaller units. That our pre-treatments have not inactivated the agent is shown by our biological results. Neither are the particles artefacts, for distilled water extracts of fresh tissues are also found to contain them.

It is to be noted, too, that Graff and his colleagues appear not yet to have obtained and tested supernatants free from their particles.

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Ground-Wave Propagation Across a Land/Sea Boundary

No useful analytical solution has yet been given for the propagation of vertically polarized radio waves over a non-homogeneous earth. On one hand, Grünberg[1] and other Russian authors have started analytical work on the right lines, but seemingly without being able to arrive at any reasonable answers; on the other, Millington[2] has suggested a practical graphical procedure, based on the general features that a rigorous solution would be expected to possess. Millington's method ignores phase relationships altogether; but recent experimental work indicates that it gives a good estimate of field-strengths[3,4,5].

I have now been able to show that the case of a single land/sea boundary for a flat earth may be adequately treated by an integral equation method allied to that recently introduced into diffraction theory[6,7]. In particular, the two-dimensional problem illustrated in Fig. 1 can be solved exactly. In this model the sea has been replaced by a perfectly conducting, semi-infinite plane sheet; and the transmitter *T* is a vertically polarized line-source (parallel to the boundary *O*) which, together with the receiver *R*, we shall for convenience take at ground-level. Essentially, we have here a generalization of the classic Sommerfeld half-plane diffraction problem; and

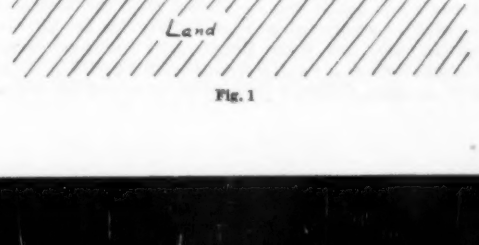

Fig. 1

when the propagation problem is viewed in this light, the possibility of a 'recovery effect' appears less remarkable than it is often described to be.

Let E represent the ground-level field (vertical component of electric field) for the conditions as in Fig. 1; let E_1, E_2, be the corresponding fields for earths all 'land' and all 'sea' (that is, perfect conductor) respectively; and let E_0 be the free-space field. Put $OT = r_0$, $OR = r$, $TR = d$. Then, to sufficient accuracy, the simplest results of interest to have been derived are as follows: (*a*) for R between T and O, $E = E_1$; (*b*) for R on TO produced, under conditions to be stated presently,

$$\frac{E}{E_0} = \frac{E_1}{E_0} + \sqrt{\frac{2r}{\pi r_0}}\,\frac{2\exp(-i\pi/4)}{\sqrt{kd}\,\sin\beta}, \qquad (1)$$

where $k = 2\pi/\lambda$ is the free-space propagation constant, and β is the (complex) Brewster angle for the land. With the field expressed in this form, restriction to a line-source is no longer necessary, provided that TR remains perpendicular to the coast-line.

Formula (1) is only valid when T is a large numerical distance from O, that is, for $(kr_0/2)\sin^2\beta \gg 1$. In this case

$$\frac{E_1}{E_0} = -\frac{2i}{kd\sin^2\beta}, \qquad (2)$$

so that the second term on the right of (1) soon predominates as r/r_0 becomes appreciable. Since $E_2/E_0 = 2$, we then have

$$E = \sqrt{\frac{2r}{\pi r_0}}\,\frac{2\exp(-i\pi/4)}{\sqrt{kd}\,\sin\beta}\,E_0 = \sqrt{\frac{2r}{\pi r_0}}\,\sqrt{E_1 E_2}. \qquad (3)$$

In Fig. 2, equation (1) has been used to plot a field-strength curve for $\sin\beta = 1/3$, $r_0 = 300\,\lambda$. Such conditions would scarcely be met in practice, but are chosen to make E_1 and E_2 strikingly different, so that a marked recovery effect is obtained. The curve derived from Millington's graphical method is shown dotted. At $r = r_0$ his procedure always gives, as regards field-strengths,

$$E = \sqrt{E_1 E_2}, \qquad (4)$$

which differs from (3) by the factor $\sqrt{2/\pi}$, representing a reduction of 2 db. As r tends to infinity, Millington's curve also lies 2 db. above the accurate one, so that the two differ for the most part by this amount, though they become remarkably close as the boundary is approached.

For the case considered, Millington's argument has no theoretical support, since (4) can only be justified when r and r_0 represent large numerical distances for *both* media. In so far as it is permissible to seek such accuracy, the only relevant experiment[3] tends to confirm that, when one of the media is a quasi-conductor, Millington's method gives field-strengths about 2 db. too great.

If T and R are at arbitrary heights h_T and h_R, the formula corresponding to (1) is much more complicated. However, it is simplified again if (*a*) h_T and h_R are both sufficiently great for ray theory to apply in the case when the earth is all land; in the example chosen, this requirement is $h_T h_R > 2\lambda$; (*b*) R lies on $T'O$ produced, where T' is the image of T in the earth's surface. Under these conditions, taking $h_T = h_R$, it can be shown that the expected height-gain relationship is valid for h_T up to $6\,\lambda$. Furthermore, use of the height-gain factor to derive the field for $h_T = h_R = 0$ from that for $h_T = h_R = 2\lambda$ gives a value differing from that obtained by direct

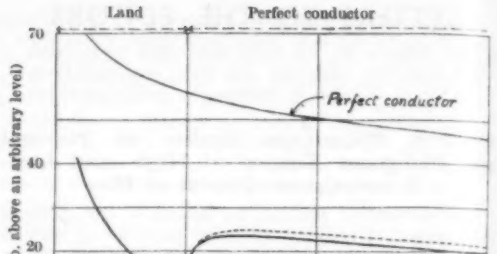

Fig. 2

application of (1) by only 0·1 db. This affords a valuable check on the calculations.

Finally, it may be mentioned that the above method can be applied to the case of two arbitrary media, if use is made of approximate boundary conditions which are valid in view of the rapid attenuation of waves below the earth's surface (see, for example, ref. 1). The formulæ for this general case are naturally more complicated, but are capable of giving numerical results.

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Macroscopic Space Charge in Electrolytes during Electrolysis

Since the publication of Hittorf's famous paper in 1853, it has been assumed, in general, that in every small element of volume of an electrolyte undergoing electrolysis, the sum of the charges on the negative ions is equal to the sum of the charges on the positive ions, namely, that during electrolysis macroscopic space charge does not exist. Apparently, Hittorf based this assumption on some experimental results which were obtained by Faraday in 1831.

Macroscopic space charge is known to exist in a uniformly ionized column of a gas which is conducting an electric current. Since the column of electrolyte is also uniformly ionized throughout, and since the current in each consists of positive ions moving toward the cathode together with negative ions moving toward the anode, it seems reasonable to expect that macroscopic space charges might exist in an electrolyte during electrolysis.

Apparatus and procedures were developed which permitted the accurate determination of the potential distribution along a uniform column of electrolyte during electrolysis. The potential was found to be a non-linear function of the distance from the cathode, and it was shown that this non-linearity could not be

due to concentration changes brought about by the electrolysis. It was also shown that this non-linear relation could exist only if macroscopic space charges existed in the electrolyte.

The distribution of the macroscopic space charge along the column was calculated from the potential distribution. In every case it was apparent that the column of electrolyte contained four space-charge regions. Very near the cathode the charge was positive. The next quarter of the column contained negative space charge. Very near the anode the space charge was negative. The remainder of the column (about three-quarters of it) contained positive space charge. The largest space charge was observed within 1 mm. from an anode; it required an excess of 2,000,000 Cu^{++} ions over the SO_4^{--} ions per c.c., an excess of only 3 ions for every 10^{13} Cu^{++} ions originally present. The space charges in other parts of the column were very much smaller than this.

The distribution of the electric field-strength along the column of electrolyte was also calculated from the potential distribution. Although the magnitudes of the space charges were very small, they had very appreciable effects on the field-strengths. For example, the observed mean potential gradient in the explorable part of the 40-cm. long column (to within 1 mm. of each electrode) was 16 per cent less than the average potential gradient $\left(\frac{8000}{40}\text{ mV./cm.}\right)$ in the cases of two solutions. Since the actual field-strengths are not constant and are so much different from those calculated from the potential difference between the electrodes and their distance apart, any direct-current method for determining electrolytic conductivity must take space charge effects into account.

The eight electrolytes studied were 0·0024 *N* solutions of copper, zinc and nickel sulphates and chlorides, zinc acetate and aluminium sulphate. In each case the column of electrolyte was 40 cm. long by 8 cm. wide by 8 cm. deep, and the electrodes were made of pure metal, the metal being that of the positive ions.

The results of this research force one to the conclusion that macroscopic space charges do exist in an electrolyte during electrolysis, and that this phenomenon is more complicated than it is in uniformly ionized gases. It is expected that this newly discovered phenomenon will cause a re-examination of the theories concerning electrolysis.

A detailed account of this work will appear in the very near future in the *Journal of Chemical Physics*.

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Supersonic Vibration Potentials (Debye Effect) in Colloidal Solutions

The interesting results reported by Yeager, Bugosh, Hovorka and McCarthy[1] with respect to the Debye effect in electrolytic solutions induce us to give an account of the results obtained by us in recent years in colloidal solutions.

The apparatus used was similar to that described before[2], so we will give here only the main points of difference from the original apparatus. The radio-frequency generator consisted of a 100-watt Hartley oscillator and a push–pull amplifier stage utilizing two 500-watt tubes. The amplifier consisted of a high-frequency amplifier stage, converter and two intermediate-frequency amplifier stages; maximum amplification 700,000. This amplification factor turned out to be much larger than necessary in our colloidal solutions of arsenic trisulphide (in our previous experiments we used silver iodide). It was reduced to 22,500. The background noise was equivalent to $\pm 3\ \mu V$.

We tried to measure the velocity amplitude of the supersonic wave by measuring the acoustical pressure, by means of a hydrostatic balance with a hollow prism; but, like Yeager *et al.*, we could not obtain satisfactory results.

Our colloidal solution of arsenic trisulphide contained 163 gm. of As_2S_3 per litre; the electric conductivity was $73 \times 10^{-6}\ \Omega^{-1}\ cm.^{-1}$, the viscosity $\eta = 0{\cdot}013$ c.g.s.

The Debye effect was quite large in this solution; the potentials measured in the solution varied from 45 V. maximum to 12 V. minimum, which yields, after division by 22,500, an amplitude for the supersonic vibration potential of $33{,}000/22{,}500 = 1{\cdot}47$ mV.

For an (estimated) velocity amplitude $v_0 = 2{\cdot}75$ cm./sec., and a ζ-potential of 100 mV., our simple formula[2]

$$\Phi_0 = \frac{mnD\zeta v_0 g}{4\pi\eta\sigma}$$

leads to 7 mV.; therefore, the discrepancy between theoretical and experimental values, reported in our previous note (factor 100), is less serious now.

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Double Orbit in the 30-MeV. Synchrotron

An examination of the shape of the gamma-ray output pulse of the Malvern 30-MeV. synchrotron[1] shows two distinct pulses, both when the machine is working as a synchrotron and as a betatron. When the machine is working as a synchrotron, both pulses occur after the radio-frequency is switched off, one at the expected time, the other much sooner.

The existence of the earlier (or spurious) pulse may perhaps be explained in terms of a resonance phenomenon (discussed by Courant[2]) between the second harmonic of the betatron oscillation frequency and the angular rotational frequency.

The equation for radial oscillations about the equilibrium orbit of a betatron to the first order is

$$\ddot{\rho} + (1 - n)\,\omega^2\rho = 0, \qquad (1)$$

where ρ is the displacement of the electron, ω is the angular rotational frequency and n is $-d(\log H)/d(\log r)$, H being the axial field at a radius r. Thus when $n = 0{\cdot}75$, the oscillation frequency is equal to half the rotational frequency, since $(1 - n)^{1/2}\,\omega = 0{\cdot}5\,\omega$.

If n is nearly equal to 0·75, the position of maximum ρ will slowly precess. Now equation (1) is only a first-order equation, but in general there are small terms also in ρ^2 and $\dot{\rho}^2$, which make the solution of equation (1) a complicated function, in which the frequency is dependent on the amplitude. The

second-order terms have been investigated in detail by W. Walkinshaw (unpublished), who has shown that they are large enough to produce a frequency change of the order of 3 per cent for an oscillation amplitude of about 8 per cent of the orbit radius. Thus it might happen that even if the oscillation amplitude maximum precessed for small oscillations, an oscillation amplitude might exist such that no precession occurred. In this case a small circumferential inhomogeneity would act as a forcing term of exactly twice the oscillation frequency. This would cause a resonance of fixed amplitude. In such a resonance (which is analogous to 'ferro-resonance' which can occur with a saturating choke the inductance of which varies with current), the phase of the oscillation sets itself such that the force integrated with respect to the displacement over one cycle is equal to the energy lost per cycle, in this case zero. It can be shown that such an oscillation is stable over a limited region, and if perturbed the oscillation amplitude will oscillate about the unperturbed amplitude. This type of resonance can only be started by somehow giving the electron a large displacement: it cannot build up from a small oscillation, because the natural frequency for small oscillations is not related to the forcing frequency.

If at injection the electrons have a range of oscillation amplitudes, some will damp down to the equilibrium orbit, and others will damp down to an oscillation of fixed amplitude about the equilibrium orbit.

When the radio-frequency is switched off, both these orbits will contract and the spurious orbit will probably lose its phase relationship with the inhomogeneity, but will continue as a free oscillation of large amplitude, thus hitting the target before the true orbit by a time dependent on the oscillation amplitude.

To test this hypothesis, pieces of laminated iron were placed around the magnet just outside the pole pieces. These produced disturbances in the field, and altered the relative sizes of the two pulses. Positions could be found which put the electrons completely in one or other of the two orbits, and it was observed that when the spurious orbit was eliminated there was no significant change in output.

In view of the very special shape of magnetic field required, it is strange that this phenomenon occurs on the Malvern machine, since measurements of the magnetic field indicate a value of n rather less than 0·75.

This phenomenon, though interesting, is not likely to occur often in practice, since the magnetic field must be a very special shape before the two orbits can both occur within the confines of the 'donut'. Even if it does occur, however, the effect would not appear to be serious, since any electrons which can get into the spurious orbit in the first place are likely to stay in the 'donut' unless the betatron equilibrium orbit changes significantly during the betatron phase. The energy difference between the two pulses also will be too small to be important.

I wish finally to acknowledge helpful discussion on this question with Messrs. Walkinshaw and Goward, of the Atomic Energy Research Establishment.

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Phase-Shift Formula for Many-Body Collisions

We consider the scattering of a particle (**R**) with momentum **K** and mass M by a nearly spherically symmetrical system of N particles ($\mathbf{r}_s$), taking into account the 'adiabatic' deformation of the scattering system during the collision.

In the time-independent Schrödinger equation for the total system of the $N+1$ particles (**R**) and ($\mathbf{r}_s$), we replace the interaction potential $V(\mathbf{R}, \mathbf{r}_1, \ldots, \mathbf{r}_N)$ by the effective potential $V_l(R, \mathbf{r}_l)$. The latter is defined as follows: we average the interaction potential over the angles of the vectors $\mathbf{r}_s$; the resulting dependence on R and $\mathbf{r}_s$ we approximate by the form $V_l(R,\mathbf{r}_l)$, choosing suitably the function $\mathbf{r}_l = \mathbf{r}_l\{r_1, \ldots, r_N\}$. The index l indicates the dependence of the function $V_l(R,\mathbf{r}_l)$ and of the 'mean distance' $\mathbf{r}_l$ on the azimuthal quantum number l of the incoming particle. For collisions with heavy atoms, a different $\mathbf{r}_l$ may be introduced for each electron shell. We expand the solution of the Schrödinger equation of the system ($\mathbf{R},\mathbf{r}_s$) with the effective potential in a series of spherical harmonics referring to the angular co-ordinates of the incoming particle:

$$\Phi(\mathbf{R}_1\mathbf{r}_1, \ldots, \mathbf{r}_N) = \sqrt{\frac{\pi}{2}}\,\frac{1}{KR}\,\Sigma\,(2l+1)\,i^l F_l(R,\mathbf{r}_l)\,P_l(\cos\theta_R)\,\varphi_l(\mathbf{r}_1, \ldots, \mathbf{r}_N). \quad (1)$$

The F_l are defined as the solutions of the radial part of the Schrödinger equation for the particle (**R**) in the effective potential $V_l(R,\mathbf{r}_l)$. In this Schrödinger equation r_l is to be understood as a fixed parameter. The functions F_l are subject to boundary conditions of the usual type chosen so that they are normalized to unity with respect to the variable R.

By inserting the expansion (1) in the Schrödinger equation of the total system with the effective potential $V_l(R,\mathbf{r}_l)$, we get for the coefficients $\varphi_l(\mathbf{r}_1, \ldots, \mathbf{r}_N)$ the Schrödinger equation of the scattering system ($\mathbf{r}_s$) perturbed by the potential (expressed in Hartree units) due to the incoming particle (**R**):

$$U_l(r_s) = \sum_{s=1}^{N}\left\{M\pi\int_0^{\mathbf{r}_l^*}\frac{\partial V_l(R,\mathbf{r}_l)}{\partial r_s}\,F_l^2(R,\mathbf{r}_l)dR\right\}^2 \quad (2)$$

where $\mathbf{r}_l^* \equiv \mathbf{r}_l^*\{\mathbf{r}_l\}$ is a given function of $\mathbf{r}_l$; for $\mathbf{R} \geqslant \mathbf{r}_l^*$ we have $\dfrac{\partial V_l(R,\mathbf{r}_s)}{\partial r_s} = 0$.

By using the Hartree procedure, this equation may be split up into N one-particle Schrödinger equations and treated further by the perturbation method.

From our approximate solution (1), the phase shift can be derived by considering only the asymptotic behaviour at $R \to \infty$ of the solution $\Phi(\mathbf{R},\mathbf{r}_s) \to \sum X_n(KR)\chi_n(\mathbf{r}_s)$ without the usual[1] assumptions about the solution at finite distances. Here $\chi_u(\mathbf{r}_s) \equiv \chi_u(\mathbf{r}_1, \ldots, \mathbf{r}_N)$ are the unperturbed eigenfunctions of the system of ($\mathbf{r}_s$) particles. Thus it is possible to get the phase shift for inelastic scattering with the simultaneous excitation or ejection of several ($\mathbf{r}_s$) particles. The general formula is too complicated to be given here. In the case of elastic scattering by a spherically symmetric system, we get (Hartree units)

$$\sin \eta_l = -\sqrt{\frac{\pi}{2}}\,\frac{2M}{K}\int d\tau_s\, \varphi_l(\mathbf{r}_s)\,\chi_s(\mathbf{r}_s)\int dR$$

$$\sqrt{\frac{\pi}{2}KR}\,J_{l+1/2}(KR)\,V(\mathbf{R},\mathbf{r}_s)\,.\,F_l(R,\mathbf{r}_l\{\mathbf{r}_s\}), \quad (3)$$

where $\mathbf{r}_s$ stands for the set $\mathbf{r}_1, \ldots, \mathbf{r}_N$ and $d\tau_s$ for the product $d\tau_1, \ldots, d\tau_N$. This formula gives either the Born approximation when the potential $V(\mathbf{R},\mathbf{r}_s)$ tends to zero, and therefore $F_l(R,\mathbf{r}_l) \to \sqrt{RK}\,J_{l+1/2}(KR)$, or the partial cross-section formula when we assume a rigid potential putting $V(\mathbf{R},\mathbf{r}_s)$ and thus also $F_l(R,\mathbf{r}_l)$ independent of r_s. (For $l \neq 0$ when the velocity V of the ($\mathbf{R}$) particle tends to infinity, (3) gives Born approximations for phase shift.)

The application of the above method to the cases of elastic scattering of negative mesons by atoms and of neutrons by deuterons is in preparation and will be published elsewhere.

I should like to express my gratitude to Prof. L. Rosenfeld for his help and encouragement.

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Utilization of Aspartic Acid and Asparagine by Yeast

Much work has been carried out upon the mechanisms whereby yeast is able to utilize nitrogen from amino-acids for its nutrition, and the mechanisms worked out by Ehrlich and Stickland illustrating nitrogen uptake are well known[1,2]. These and other authors (for example, Thorne[3]) have been concerned with the value of amino-acids to yeasts simply as sources of nitrogen. Working with aspartic acid and asparagine, however, we have for some time observed that yeast growth has been stimulated under some conditions to a remarkable extent if either aspartic acid or asparagine has been present in nutrient solutions containing sugars and inorganic salts and nutrilites under various conditions of wort aeration. Under several conditions of experimental procedure, always with good aeration, it has been found that aspartic acid and asparagine added in relatively large amounts have always had the effect of increasing the yield of yeast obtained from a standard amount of fermentable sugar. Thus, under one set of conditions, it has been found that the addition of 1 gm. of asparagine would yield an additional 2·7 gm. of yeast (at 27 per cent dry matter) or 0·729 gm. of yeast dry matter. Also, while we have never been able to obtain yields of yeast (at 27 per cent dry matter) greater than 210 per cent of the hexose sugar supplied, this figure has, under some conditions, been greatly exceeded when either aspartic acid or asparagine has been present in the wort in sufficient amount.

These facts we attribute to the assimilation of the amino-acids as such by the growing yeast, the carbon skeleton of those substances being taken into the yeast. The mechanisms of Ehrlich and Stickland both neglect the possibility of assimilation of amino-acid *carbon* by yeast. If all the carbon of asparagine were assimilable by yeast, 1 gm. of asparagine (0·363 gm. carbon) would give 0·77 gm. of yeast dry matter (carbon average, 47 per cent). This assimilation can take place only when the yeast is at the same time supplied with fermentable sugars (probably as a source of the energy necessary to enable the assimilative mechanisms to proceed). Assimilation of the two amino-acids and subsequent yeast growth can, however, take place in the absence of biotin.

Recent work[4,5] has suggested that bacterial cell substance may be synthesized from sugars and ammonia in the following manner. Pyruvic acid (from normal fermentative breakdown of hexose) combines with carbon dioxide to form oxalacetic acid. This then combines with ammonia to form aspartic acid, which is presumed to form the basis for protein structure of the bacterial cell. Biotin is stated to catalyse part of this chain of reactions.

It appears to us that our observations may quite easily be explained upon such a basis as the above. If the normal yeast assimilative mechanism (by which hexose-sugar carbon and ammonia nitrogen are combined to form cell protein) passes through the stages noted above, it could be presumed that aspartic acid (or its amide asparagine) could be true intermediates in cell synthesis. In such a case, biotin would not be needed if aspartic acid (or amide) were supplied to the yeast, and such certainly does appear to be the case. The fermentable sugar is necessary to provide energy and probably other carbon groups for later cell anabolism.

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The Precipitin Reaction and Antibody Valence Studied with the Aid of Radioactive Isotopes

Heidelberger and his colleagues[1] have made extensive quantitative studies of serological reactions using micro-methods for the determination of total nitrogen in specific precipitates, supplemented by the determination of the amount of dye present when dye-azoproteins were used as antigens. Other investigators have used antigens containing iodine[2], copper[3] and iron[4] to enable the amount of antigen to be determined in precipitates obtained from a wide range of mixtures of antigen and antibody.

For various immunochemical investigations during the past few years[5,6,7] we have been using antigens and antibodies labelled with radioactive isotopes. As antigens we have used lipovitellin containing phosphorus-32, proteins treated with mustard gas sulphone containing sulphur-35, and iodinated proteins containing iodine-131. We have also used antibodies labelled with iodine-131 or sulphur-35, for we have found that the introduction of small amounts of iodine or mustard gas sulphone groupings into antibodies, such as those to egg albumin, serum globulin

Composition of precipitates obtained with iodinated ovalbumin and antisera to iodinated horse serum globulin
All the weights given refer to amounts/ml. antiserum used.

Mixture	Antigen added		Composition of the precipitate				
	N (μgm.)	I (μgm.)	Total N (μgm.)	Total I (μgm.)	Antigen N (μgm.)	Antibody N (μgm.)	Mol. ratio* antibody/antigen
a	47·8	23·6	272	15·2	30·7	241	1·9
b	23·9	11·8	242	8·4	17·1	225	3·2
c	8·0	3·9	122	2·8	5·6	116	5·0

* Calculated on the basis of nitrogen contents and molecular weights of 15·76 per cent and 40,500 for egg albumin, and 16 per cent and 165,000 for the antibody.

and lipovitellin, does not destroy the ability of these antibodies to form specific precipitates with appropriate antigens.

A few typical results obtained in experiments with iodinated ovalbumin containing iodine-131 and an antiserum against iodinated protein are given in the accompanying table to indicate the use of the method. The results recorded here are for (*a*) mixtures with excess antigen, (*b*) in the equivalence zone and (*c*) with excess antibody. The complete analysis of the precipitate, by iodine-131 and total nitrogen determinations, can often be made in duplicate using less than 0·5 ml. of antiserum, the limiting factor being the sensitivity of the determination of total nitrogen. When iodine-131 of high specific activity is used for the preparation of the antigen, duplicate nitrogen and iodine-131 determinations are possible on as little as 0·5 mgm. of precipitate.

In experiments with the lipovitellin–antilipovitellin system, with the antigen labelled with phosphorus-32 and the antibody with iodine-131, we have been able to show that antilipovitellin sera contain relatively large amounts of antibody which react with the phospholipids of the lipovitellin antigen.

In other experiments we have been using 3 : 5-diiodotyrosine containing iodine-131 to study the inhibiting effect of this compound on the precipitin reaction between iodoproteins and their antibodies. In order to avoid removal of attached diiodotyrosine, the precipitates were not washed before analysis; but by carrying out the precipitin reaction in the presence of 5 per cent heavy water, we were able to determine the amount of supernatant solution adhering to the precipitate, and hence the uncombined diiodotyrosine.

Analyses of the precipitates obtained with varying amounts of antigen, antibody and inhibitor have shown that the amount of combined inhibitor in the precipitates is very small or possibly zero; it is certainly less than one molecule per twenty molecules of antibody. We believe that these results offer strong support for the view that the antibodies we have studied are univalent in the sense that each molecule has only one specific combining group for the corresponding antigen. Antibody valence is still the subject of controversy (see reviews in refs. 8 and 9), and while some authorities favour the theory of univalence, others believe in multivalence or at least bivalence. We are hoping that the use of antigens and antibodies labelled with radioactive isotopes may throw further light on this problem. A more complete account of our results will be given elsewhere.

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Significance of Tryptophane in Human Nicotinic Acid Metabolism

There is much evidence that tryptophane can replace nicotinic acid in the nutrition of the rat (for literature, see Spector[1]); but relatively little is known about the significance of tryptophane in human metabolism of nicotinic acid. Perlzweig *et al.*[2], and Sarett and Goldsmith[3,4], demonstrated an increase in the urinary excretion of N-methylnicotinamide after oral administration of *l*- or *d,l*-tryptophane to humans; but since this substance is not the main metabolite of nicotinic acid[5,6], and since its fate in the body is still not clear[7], it is not possible from their results to estimate with any degree of certainty the amount of nicotinic acid produced from the dose of tryptophane.

Since it is now known that N-methyl-2-pyridone-5-carboxylamide is the chief metabolite of nicotinic acid[5,6], and since a specific colorimetric method is available for its determination in urine[6], an experiment was made to study the effect of ingestion of *l*-tryptophane on the urinary excretions of N-methylnicotinamide and N-methyl-2-pyridone-5-carboxylamide by humans. Two healthy adult Europeans (subject 1 a male of 34 years; subject 2 a female of 36 years) were given a diet consisting of everyday foods (white bread, butter, jam, beef, peas, potatoes, fruit, breakfast cereal and tea) in amounts which satisfied their usual appetites. The amount of each food eaten daily was kept constant throughout the experiment. The diet was sampled and analysed for nicotinic acid by the method of Dann and Handler[8]. The urinary excretions of N-methylnicotinamide (method of Huff and Perlzweig[9]) and N-methyl-2-pyridone-5-carboxylamide (method of Holman and de Lange[6]) were determined on successive 48-hour periods before and after the ingestion of *l*-tryptophane (6 gm. on two successive days).

The results (Table 1) show a considerable rise in the excretions of N-methylnicotinamide and, particularly, of N-methyl-2-pyridone-5-carboxylamide

Table 1. Effect of *l*-tryptophane on the urinary excretion of metabolites of nicotinic acid by humans.
(NA = nicotinic acid; NMN = N-methylnicotinamide; P = N-methyl-2-pyridone-5-carboxylamide)

Subject No.	48-hr. period No.	Dietary intake of NA (mgm.)	*l*-Tryptophane supplement (gm.)	Urinary excretion (mgm.)	
				NMN	P
1	1	79·2	0	13·0	27·4
	2	83·3	0	10·1	22·1
	3	85·5	0	14·5	24·9
	4	78·1	0	17·1	31·1
	5	79·0	12	44·3	87
	6	78·1	0	24·3	71
	7	69·2	0	21·3	45·8
2	1	38·3	0	8·4	13·8
	2	46·1	0	10·0	12·5
	3	45·0	0	8·3	12·9
	4	44·0	0	8·8	12·0
	5	46·5	12	35·1	137
	6	40·3	0	19·3	53
	7	39·3	0	14·4	25·6

following the dose of tryptophane. Since the increase was shown by both metabolites, and since the specificity of the method for the latter compound has been studied in some detail[6], there can be little doubt that a relatively large amount of nicotinic acid was formed from tryptophane. The extra amounts of N-methylnicotinamide and N-methyl-2-pyridone-5-carboxylamide excreted after the dose are together equivalent to 145 mgm. nicotinic acid for subject 1 and to 181 mgm. for subject 2. The amount of nicotinic acid made available to the body by the 12 gm. of tryptophane is probably still greater than this, since it was shown[6] that after the ingestion of 500 mgm. of nicotinamide only 70–77 per cent could be accounted for in the urine as N-methylnicotinamide and N-methyl-2-pyridone-5-carboxylamide. These results were obtained when a large excess of tryptophane was present in the body, and smaller amounts may not have a proportionate effect. However, it is of interest to note that 1·1 gm. tryptophane, stated to be the average daily consumption in the United States of America[10], would, if the above conditions were applicable, provide as much as 13–17 mgm. of nicotinic acid a day.

The present evidence suggests that protein deficiency, and particularly tryptophane deficiency, may play a significant part in pellagra. Preliminary results obtained in this laboratory through the helpful co-operation of Dr. Grek and other members of the medical staff of the Coronation Non-European Hospital, Johannesburg, indicate (see Table 2) that in pellagra the urinary excretion of N-methyl-2-pyridone-5-carboxylamide falls to zero, and rises after treatment with nicotinic acid and other B vitamins at a slower rate than normal. If these findings are observed in further cases of pellagra, it would be of interest to study the effect of tryptophane on the excretion of N-methylnicotinamide and N-methyl-2-pyridone-5-carboxylamide by pellagrins.

Table 2. Urinary excretion of N-methyl-2-pyridone-5-carboxylamide by pellagrins before and after treatment with B-vitamins

Subject	Sex	No. of days treatment	Urinary excretion of N-methyl-2-pyridone-5-carboxylamide (mgm./24 hr.)	
			Before treatment*	After treatment†
Bantu pellagrin	M	8	< 0·05	22·4
Bantu pellagrin	F	11	< 0·05	29·4
Normal European	M	5	13·0	59·4

* The Bantu patients were given no vitamin treatment and a normal hospital diet for the first 24 hr. while the urine specimen was collected.
† Treatment consisted of improved diet and 100 mgm. nicotinic acid, 50 mgm. pyridoxine, 50 mgm. aneurin, 5–10 mgm. riboflavin given daily by intra-muscular injection for the first five days, then orally; crude liver extract, 1–2 ml., was given by injection for the first five days. In the case of the European, the vitamins were given orally.

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External Potassium and the Membrane Potential of Single Muscle Fibres

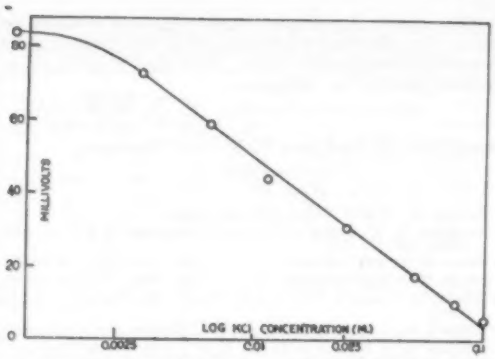
One important supporting fact for the concept of the membrane potential of muscle and nerve being a diffusion potential[1] was the demonstration of a rectilinear relationship between the logarithm of the external potassium concentration and the measured membrane potential, according to the Nernst equation:

$$\text{membrane potential} = 58 \log_{10} \frac{K^+ \text{ internal}}{K^+ \text{ external}} \text{ mV.}$$

This was shown to be approximately true by Cowan[2] for the injury potential of crab nerve and by Shanes[3] for the 'anaerobic' fraction of the injury potential of frog nerve. Doubts as to the significance of the rectilinearity of their curves[4,5] seem to be met, at least in the case of squid giant axon, by the work of Curtis and Cole[6], although these authors hesitated to ascribe the membrane potential completely to the potassium concentration gradient. Using the classical injury potential technique, a similar relationship has been demonstrated in frog muscles by Steinbach[7] and by Boyle, Conway and co-workers[8,9]. Thus a potential *v.* log $[K^+]$ relation has been found for both nerve and muscle.

There are, however, limitations to the injury potential technique; the potential falls off rapidly, and due to the uncertain short-circuiting through the interfibrillar fluids, the maximum measured potential is far below the true value. Such difficulties are overcome by the method of impaling a single muscle fibre with a micro-electrode[10]. The normal membrane potential of frog sartorius fibres was thus found to be 95 mV., approximately the value expected on theoretical grounds. (This is with 3 *M* potassium chloride filling the micro-electrodes, after Hodgkin[11]. The curve in the accompanying graph, however, was obtained with electrodes filled with isotonic potassium chloride and hence shows lower values[10].)

Varying the external potassium chloride, by substituting equimolar amount of sodium chloride in normal frog Ringer solution, gives a straight line relationship as shown in the graph. Each point on the curve represents the average of six measurements on different fibres, after having been equilibrated for 5–10 min. The general shape of the curve resembles those of Curtis and Cole and of Conway and Kane; but with the much higher values of potential obtained



and consequently the greater voltage range, the non-linear portion at low concentration of potassium ions becomes less conspicuous. Increasing potassium chloride to two or four times isotonicity caused the potential to become reversed in polarity to − 3 and − 7 mV. respectively. The average slope of eight different curves is − 44 mV. ± 9·5 mV. (S.D.), for a tenfold increase of the external potassium concentration. This is similar to slopes found in other cells and tissues by other authors[7,13], but is definitely lower than the theoretical value of 58 mV.

More extensive studies on salt effects will be presented elsewhere.

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Reversal of Glycogenetic to Glycogenolytic Action of Desoxycorticosterone in Rats

IT was shown in a series of papers from this Laboratory that desoxycorticosterone has *in vitro*, in the concentration of 1–5 mgm. per cent, an inhibitory effect on glycogen formation[1–4] of the isolated muscle, which has since been explained as a glycogenolytic action[5]. This was the more unexpected since it seems certain that this adrenal cortical steroid has in the intact animal a distinct glycogenetic action[6–8]. We therefore tried whether it might be possible to reverse also the glycogenetic activity of desoxycorticosterone in the intact animal by increasing the dose to an inhibitory or glycogenolytic one.

The experiments were performed on normal and on adrenalectomized male rats of 150–200 gm. weight on the stock diet. For experiments with normal rats the animals were fasted for 24 hr. Then desoxycorticosterone acetate in the doses given in Table 1 was injected in oily solution intraperitoneally. One hour later, 2 c.c. of 50 per cent glucose solution was given by stomach tube. After three hours, the animals were killed and glycogen estimated in liver and muscle in the usual way[7]. Table 1 shows the results.

Table 1. NORMAL ANIMALS

Series	Normal rats	No. of animals	Glycogen (gm. %) Liver	S.E. ±	Muscle	S.E. ±	Treatment: desoxycorticosterone acetate intraperitoneally
1	24 hr. starved	5	0·10	0	0·25	0·03	—
2	3 hr. after 1 gm. glucose	5	3·31	0·43	0·55	0·04	—
3	,,	5	1·89	0·16	0·44	0·03	2 mgm.
4	,,	5	0·71	0·19	0·25	0·04	20 mgm. (narcotic dose)

Normal animals after 24 hr. fasting have very low liver and muscle glycogen values (series 1). If they are fed 1 gm. glucose, the liver glycogen is raised to 3·31 per cent and muscle glycogen to 0·55 per cent (series 2). If, 1 hr. before feeding glucose, 20 mgm. desoxycorticosterone acetate was injected intraperitoneally and the animal went into a narcosis-like state, scarcely any glycogen was produced either in the liver or in the muscle (series 4). With 2 mgm. desoxycorticosterone (series 3) the glycogen production was somewhat smaller than in the normals.

The same was observed in adrenalectomized animals. Adrenalectomy was performed as usual from the back and the animals were treated for the first three days with 3 mgm. desoxycorticosterone daily in order to combat the post-operative shock. During the next three days they were not treated, and then fasted for 24 hr. They were then given desoxycorticosterone by injection in different doses (see Table 2). One hour afterwards, 2 c.c. of 50 per cent glucose solution was given by stomach tube. Three hours later they were killed and the liver glycogen was estimated. Table 2 shows these results.

Table 2. ADRENALECTOMIZED ANIMALS

Series	Rats	No. of animals	Glycogen in liver gm. %	± S.E.	Treatment: desoxycorticosterone acetate intraperitoneally (mgm.)
5	adrenalectomized, 3 hr. after 1 gm. glucose	5	2·59	0·28	0·1
6	,,	5	1·76	0·49	0·5
7	,,	5	1·84	0·56	1·0
8	,,	5	2·04	0·57	2·0
9	,,	5	1·59	0·22	6·0
10	,,	5	1·07	0·36	10·0*
11	,,	5	0·37	0·13	20·0†
12	normal controls	6	3·67	0·39	—

* Incomplete narcosis. † Complete narcosis.

The injection of 0·1–2·0 mgm. desoxycorticosterone caused production of glycogen from glucose; but with 10 mgm. desoxycorticosterone intraperitoneally, less glycogen was formed; and with 20 mgm. desoxycorticosterone, which produced narcosis, no glycogen was formed (series 5–11). For comparison we have at the same time, together with these adrenalectomized animals, again used six normal

animals without desoxycorticosterone treatment (series 12). They showed a glycogen production equal to that in series 2.

Thus, whereas desoxycorticosterone has glycogenetic properties if given during a longer period to adrenalectomized rats, we have succeeded with single large doses in inhibiting totally the glycogen-production from glucose. These large doses have a narcosis-like effect (Selye[9]), which might be the result of a similar inhibition of the metabolism of the central nervous system.

Desoxycorticosterone thus has an effect on glycogen production and also on glycogen breakdown. Whereas with small doses the former becomes apparent, with large doses, on the contrary, glycogen formation is inhibited in the intact animal just as in the isolated surviving muscle.

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Production of Antisera in Rabbits using Calcium Alginate as an Antigen Depot

The production of agglutinating and precipitating antisera in rabbits is normally a slow, painstaking process requiring numerous intravenous inoculations. This is especially true of streptococcal antisera. Inoculation of the antigen in a bland excipient which would be slowly enough absorbed to create a constant immunizing process would obviate the necessity for these repeated intravenous inoculations. I believe that calcium alginate fulfils this requirement.

The alginates are salts of alginic acid derived from seaweed. The calcium salt in 5 per cent aqueous concentration forms a gel which will not pass through even a wide-bore needle. A 5 per cent solution of the sodium salt is a viscous fluid which, on the addition of one per cent calcium chloride, is changed immediately into the calcium gel. For parenteral administration the inoculum is mixed with 5 per cent sodium alginate, and this is converted into calcium alginate by the immediate injection of a half volume of 1 per cent calcium chloride into the same site. The *p*H of the sodium alginate was 7·2 in the present work. Increasing the alkalinity is said to increase the rate of absorption.

Rabbits were anæsthetized with ether, their bellies clipped and a 1·0-ml. concentrate of 100–200 ml. of dead broth culture was emulsified in 4·0 ml. of 5 per cent sodium alginate and inoculated intraperitoneally. Immediately afterwards, 2·5 ml. of 1 per cent aqueous calcium chloride was inoculated into the same site. Test bleedings made from the ear three weeks to a month later showed unsatisfactory antibody response. The animals were then given a single large intravenous dose in some instances or three doses at four-day intervals in others. Ten days after the last intravenous inoculation, test bleedings were made again. In all cases the sera had agglutinin and precipitin titres as good as, or better than, those obtainable by any other method. Antisera were produced against the following organisms: *S. typhi-murium* (OH); *Staph. pyogenes*; *Str. agalactiæ* (eight strains); *E. coli* (OH); *Proteus* (OH); *Erysipelothrix rhusiopathiæ*; *Erysipelothrix monocytogenes*; *S. choleræ-suis* (OH).

The OH titres of the *E. coli* and *S. choleræ-suis* antisera were ++++ at 1–25,600, while the *Str. agalactiæ* antisera agglutinated well at 1–1,280 to 1–2,560. The *E. coli* rabbit received only a single intravenous inoculation. All the *Str. agalactiæ* antisera gave good immediate reactions to the Lancefield precipitin test[1]. I have been engaged for the past four years in the production of *Str. agalactiæ* antisera, and the results show that only about a third of the rabbits inoculated according to the Lancefield method give satisfactory antisera of research standard.

It is generally well known that when the reticulo-endothelial system has been conditioned to the reception of a given antigen, even although the blood antibody titre has been allowed to fall to a low level, a subsequent inoculation of the same or a related antigen is sufficient to raise the titre to a high level again. It is also known that serum-producing animals which have traces of antibody before immunization produce sera of higher titre than those with no preliminary antibody; for example, horses with traces of diphtheria antitoxin.

The rationale of the present method is to condition the reticulo-endothelial system over a period of three weeks to a month to the reception of continuous small doses of antigen by release from the alginate as the latter is absorbed, and to follow this by intravenous inoculation of tolerable doses of the same antigen so as to flood the reticulo-endothelial system and thereby increase antibody production. I recommend the intraperitoneal inoculation of a 1·0-ml. concentrate of culture emulsified in 4·0 ml. of 5 per cent sodium alginate, followed immediately by massage and the inoculation of 2·5 ml. of 1 per cent calcium chloride into the same site. The animal is then left for three weeks to a month and given three inoculations at four-day intervals of the same antigen intravenously. A test bleeding is made ten days after the last inoculation.

In the instance of the present *Str. agalactiæ* antisera, 100 ml. of twenty-four hour glucose broth culture was given intraperitoneally, and this was followed three weeks later by three intravenous inoculations of 20 ml. of the same culture given at four-day intervals. All these amounts had been concentrated to 1·0 ml.

I think that this method of immunization should replace the usual one of intermittent intravenous inoculation of graded dosage for the production of antibacterial sera. Less work is involved, and it is very much safer for the life of the animal. Because the bacteria are entrapped in the alginate, numbers far in excess of the lethal dose can be given. In the present work, rabbits killed six weeks after the alginate inoculation still had encapsulated collections of alginate in the peritoneal cavity. Histological examination of these showed them to be finely intersected with trabeculæ rich in reticulo-endothelial

cells. The intraperitoneal route was chosen because a plentiful supply of blood vessels and reticulo-endothelial cells is available there.

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Effect of Calcium and Atropine on the Histamine- and Acetylcholine-induced Contraction of Unstriated Muscle

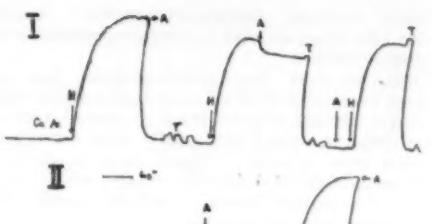
Several authors have attempted already to influence the action of histamine with atropine. The amount of atropine required to block the effect of acetylcholine does not affect the action of histamine on unstriated muscle[1]. According to Forst[2] and Feldberg[3], the contraction induced by histamine in unstriated guinea-pig muscle is only slightly diminished by small doses of atropine.

Our experiments were carried out on an isolated strip of guinea-pig ileum suspended in the usual way in Tyrode's solution in a Magnus flask. Fifty-two experiments on fourteen strips of five pieces of guinea-pig ileum showed that calcium chloride in the end concentration of 10^{-3} gm./ml. markedly diminished the size of contraction brought about by histamine (end concentration 10^{-7} gm./ml.). If, at the peak of such a calcium ion – histamine contraction, atropine (end concentration 10^{-6} gm./ml.) was added, the strip relaxed. If, on the other hand, atropine was administered together with calcium ion previously to histamine, histamine remained ineffective. Atropine, in presence of calcium ion, thus causes relaxation or inhibition of histamine contraction (see Fig. 1).

The contraction caused by calcium ion with histamine is also relaxed by 'Antistin' (Ciba 2-phenyl-benzylaminomethyl-imidazoline-hydrochloride) in an end concentration of 10^{-6} gm./ml. as well. Contractions caused by histamine in the end concentration of 10^{-7} gm./ml. without additional calcium (see above) were very little affected by this dose of atropine and could not be inhibited by previously administered atropine. To determine whether changes in osmotic pressure of the system caused by additional calcium chloride were responsible for the effects reported, a control series was run using equimolar quantities of sodium chloride instead of calcium chloride. Under these conditions, atropine did not affect the histamine contraction.

We also examined the effect of calcium chloride (for doses, see above) on contractions caused by acetylcholine (end concentration 2×10^{-7} gm./ml.). In thirteen experiments on seven strips of intestine from three guinea-pigs, we found that calcium increases acetylcholine-induced contractions.

It is well known that intestinal strips gradually lose sensitivity against acetylcholine when repeatedly treated with atropine, even after most careful washing, retaining at the same time full sensitivity against histamine. If a strip thus treated is put into Tyrode's solution containing 10^{-3} gm./ml. calcium chloride and 2×10^{-7} gm./ml. acetylcholine (end concentrations) —which has previously proved to be ineffective—the strip responds with a larger contraction to the



Ca, 10^{-3} calcium chloride; Ac, 2×10^{-7} acetylcholine; A, 10^{-6} atropine; T, three washings with Tyrode's solution; H, 10^{-7} histamine hydrochloride. (All numerals represent gm./ml. end concentrations)

Fig. 1. Acetylcholine potentiates in presence of calcium ions the action of histamine. The contraction is relaxed by atropine. Contractions caused by histamine alone are not influenced by atropine given either before or after histamine

Fig. 2. Atropine in presence of calcium ions blocks or relaxes contractions caused by histamine. Acetylcholine in presence of calcium ion potentiates the action of histamine

Both curves were obtained from the same strip of guinea-pig ileum in direct succession

administration of histamine (end concentration 10^{-7} gm./ml.) than when there is no acetylcholine added (Fig. 2). Thus whereas acetylcholine by itself was ineffective, it increases, in presence of calcium ions, the histamine-induced contractions. These contractions could also be relaxed by atropine (end concentration 10^{-6} gm./ml). Calcium is essential for both the synergic action of acetylcholine and the effect of atropine.

There have been indications[4] that histamine acts on the unstriated muscle cells and on the parasympathetic nerve endings. This could explain our results: calcium ion inhibits the direct muscular action, leaving the nervous action unaffected, which would be further strengthened by the synergetic action of subliminal doses of acetylcholine.

Even though the reported changes in ionic milieu are much greater than could be expected under physiological conditions, our experiments suggest that the action of histamine is greatly influenced by ionic conditions. A full account of this work is appearing in *Arch. int. Pharmacodyn.*

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Demonstration of Glycogen and Lipids in the Cytoplasm of Human Neutrophilic Leucocytes

The cytoplasm of the neutrophilic human leucocyte contains lipid granules which can be stained with Sudan Black[1]. On the other hand, studies with the Best Carmine stain[2], with the Bauer–Feulgen method[3], and with the recent periodic acid–leucofuchsin method[4], have demonstrated the presence of glycogen

in the cytoplasm of these cells, which has been reported to stain either diffusely or granularly. By means of the phase-contrast microscope, the stained cytoplasm has been seen to be spotted; but it was not quite clear whether the spotted appearance was due to the staining of the granules or of the intergranular spaces[4].

To solve this question, attempts were made to stain both glycogen and lipids in one blood smear. After visual examination of the cytoplasmic glycogen with the periodic acid method, unfixed smears were treated in a saturated solution of Sudan Black (Grübler Co.) in 70 per cent alcohol for 5 min. Although no lipoid solvents had been used before the Sudan treatment, the lipid stain was not satisfactory. The following method, in which the order of the two staining procedures is reversed, gave good results. (1) Fixation of dried smears in 70 per cent alcohol for 5 min. or in 99 per cent alcohol for 3 sec.; may be omitted. (2) Sudan Black solution as above for 5 min. (3) Washing in 70 per cent alcohol. (4) 0·5 per cent solution of periodic acid in water for 5 min. (5) Thorough washing in running water. (6) Schiff's reagent, prepared as usual, for 15–20 min. (7) Three washings in sulphur dioxide – water, each for 5 min. (8) Running water for 10 min. (9) Drying with blotting paper, balsam.

With this method, the neutrophilic leucocytes stained black-purple. The cytoplasm was purple with fine black-brown granules, and the nucleus remained colourless. In the cytoplasm, no uncoloured spots were to be seen. Consequently, the spotted appearance of the cells in the preparations stained with the periodic acid method only (*vide supra*) is due to the lipoid granules, not stainable with the glycogen method. It is of interest that in the eosinophilic leucocyte, similarly, the intergranular spaces only are stained by the periodic acid method[4].

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Mutations Induced in *Drosophila* by Ingested Phosphorus-32

Several recent papers[1–4] have described the cytological effects of radioactive phosphorus (P^{32}) assimilated into plant tissues. As was to be expected, there was a general similarity between the structural changes so induced and X-ray changes. To our knowledge, no published account has yet appeared of the induction of gene mutations by phosphorus-32 or other radioisotopes.

It occurred to one of us that different radioactive elements, owing to their specific physiological activities, might differ in their intimate association with certain genes and therefore in the genetic changes they induced. Such differences, if they could be observed, might well provide a new line of attack on the problems of gene structure and gene function. In the search for specific genetic actions of radioisotopes, the study of mutations, which can be located precisely by tests for linkage and allelism, was likely to be more informative than the study of structural changes in the chromosomes. Work has now begun on the production of mutations by radioisotopes in *Drosophila melanogaster*.

The first radioisotope to be used was phosphorus-32, for the following reasons. It is easy to obtain and safe to handle without elaborate apparatus. As phosphorus is a major constituent of all living tissue, phosphorus-32 may be expected to be absorbed in quantities sufficient to produce workable mutation-rates. Being a constituent of nucleic acid, phosphorus will come into very intimate contact with genes, including those of the germ line. When phosphorus-32 disintegrates the nucleus is transformed into sulphur-32, thus enforcing a gross chemical change *at the site* of the late phosphorus-32 atom, in addition to any more diffuse changes due to the ionizing effect of the β-ray. Finally, as the nucleic acid is distributed all along the chromosomes, mutations induced by phosphorus-32 would be expected to serve as controls to mutations produced by elements of more specific physiological activities and, possibly, more specific mutagenic activities.

The highest dose of phosphorus-32 administered was 1 mc. per bottle (at the time of adding the solution to the bottle, two days before introducing the parent flies). This killed all the larvæ at one or another stage before pupation. Some even reached the final instar, but did not pupate. The next dosage, 0·1 mc. per bottle, drastically reduced the number of emergent treated flies, though their appearance was normal. The third dosage, 0·01 mc. per bottle, had no appreciable effect on the emergence relative to the untreated controls.

Flies emerging from the 0·1 mc. bottles were further studied. Their activity was measured with a Geiger counter at the Royal Cancer Hospital. Though the activity was variable, the mean figure was 0·0122 μc. per fly, two to three days after emergence.

Treated males were mated to *ClB* females to test the *X*-chromosomes in their sperm for mutations. 259 *X*-chromosomes gave 19 lethals and 4 visible mutations. This is an overall mutation-rate of 8·9 per cent made up of a lethal mutation-rate of 7·3 per cent and a visible mutation-rate of 1·5 per cent. The ratio of visible to lethal mutations appears to be much higher than that found for X-ray effects, namely[5], 1 to 10–20. Of the controls, 92 chromosomes showed no mutations.

There was an indication of heterogeneity in mutation-rates between flies of the two replicate treatments (5 and 6) and according to day of emergence (shown by index numbers 1, 2 and 3). The results are summarized in the accompanying table.

Series	5^1	5^2	5^3	6^1	6^2
No. of chromosomes tested	55	57	50	45	52
No. of mutations	4	3	2	8	6
Per cent mutations	7·3	5·3	4·0	17·8	11·5
Fertility	150	324	493	92	169

χ^2 for heterogeneity in mutation-frequency for the five series does not reach the 5 per cent level of probability. It is 7·425 for four degrees of freedom with a probability of 10 per cent. But the parallelism between reduction of fertility and mutation-rate is very suggestive.

The figures given for fertility are the total progenies obtained from the five treated males used for each series. It can be seen that there is a high inverse relation between mutation-rate and fertility. Since

the highest dose of phosphorus-32 killed all the larvæ, and the next highest killed most of them, it is reasonable to suppose that the survivors would have a fertility inversely related to their individual content of phosphorus-32. There is, therefore, an indication that variation in mutation-rate is due to variation in phosphorus-32 content as indicated by fertility. The decrease of mutation and increase of fertility with later emergence implies inter-larval competition for the phosphorus-32.

The overall lethal mutation-rate here observed (7·3 per cent) is the rate that would be expected[6] for an X-ray dose of 2,500 r.[3]. It is possible, by estimating the integral dose received by an individual fly during the present irradiation with phosphorus-32, to compare the relative mutagenic efficiencies of X-rays and phosphorus-32 β-particles. The treated flies had been exposed to radiation from ingested phosphorus-32 from the first larval instar. Practically all the phosphorus-32 is taken in during the five days of logarithmic growth prior to pupation. The effect of these five days is approximately equivalent to irradiation for two days at the maximum size. From pupation to insemination (the latest point at which radiation will cause mutation in the sperm), a period averaging nine days under the conditions of the experiment, the fly remains of practically constant size, and intake of phosphorus-32 is negligible. The total period of irradiation was therefore eleven days and the initial amount of phosphorus-32 present (estimated from measurements made on the ninth day) was $1{\cdot}8 \times 10^{-2}$ μc. per fly. Therefore in this period $1{\cdot}8 \times 10^{-2} \times (1{\cdot}0 - 0{\cdot}59) = 7{\cdot}4 \times 10^{-3}$ μc. of phosphorus-32 are destroyed. 1 μc. destroyed of phosphorus-32 corresponds to the absorption of 800 gm.r. in tissue[7]. Therefore the total amount of energy emitted (or available for absorption) is $7{\cdot}4 \times 10^{-3} \times 800 = 5{\cdot}9$ gm.r.

Since the *Drosophila* fly has dimensions smaller than the range of phosphorus-32 β-particles in unit density material, not all this energy will be absorbed within the fly. If the fly is considered as a sphere of radius a, then the mean path within the sphere of β-particles produced by phosphorus-32 uniformly distributed throughout it will be equal to a. If then the absorption is approximately exponential, with an effective linear absorption coefficient μ, the amount of energy absorbed within the sphere is equal to total energy emitted multiplied by $\{1 - \exp(-\mu a)\}$.

The *Drosophila* pupa is shaped like a cylinder tapered at both ends with a maximum diameter 0·8 mm. and maximum length 3 mm. The average weight of a fly is of the order of 1 mgm. and the density is nearly 1. However, for the purposes of this comparison, the fly is considered as a sphere of volume 1 c.mm., and radius therefore 0·62 mm. The value of μ in unit density material[8] is 7·6 cm.$^{-1}$, and therefore about 38 per cent of the total energy emitted is absorbed within the fly. This corresponds to an integral dose of 2·2 gm.r. The corresponding integral dose, received by a fly of weight 1 mgm. as a result of an X-ray dose of 2,500 r., is 2·5 gm.r.

It would be unwise to attach much significance to the similarity of lethal mutation-rate per gram roentgen for the two agents. For while the phosphorus-32 has been active in the flies during all stages of development, the X-rays are always applied to males containing mature sperm. It is doubtful whether the mutability of the germ track is the same at all stages. There are indications[9] that the *apparent* mutation-rate is higher in ripe sperm than in unripe sperm, possibly through cell selection eliminating mutations at earlier stages. This would mean that the real mutation-rate per gram roentgen would have to be much higher for phosphorus-32 in order to produce the same apparent mutation-rate as X-rays acting on mature sperm.

The high mutation-rate of visibles produced by phosphorus-32 (1·5 per cent) corresponds to the expectation from 12,000 r. of X-rays[9]. Such a conclusion is less reliable than that based on lethals, owing to the small number of visibles detected[4] and the personal element involved in their detection. Additional work will be required to confirm whether phosphorus-32 is really four times as efficient as X-rays in the production of visible mutations.

Further work with this and other isotopes is proceeding. From the location of the sex-linked lethals so far produced, there is no reason to doubt that the phosphorus-32 mutations, like X-ray mutations, are randomly distributed.

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Dextran as a Diluent for Univalent Antibodies

The attempts by various workers to find a satisfactory substitute for bovine albumin as a suspension medium in the (antigen + univalent antibody) reacting system have been reviewed by Mourant[1]. The polydispersoid polysaccharides known as dextrans[2] possess certain properties which we considered might enable them to replace bovine albumin in such a system. This supposition has been well substantiated in respect of the use of the substance as a diluent for univalent anti-*D* in routine grouping procedures.

Several fractions of differing molecular size-range were tested, the most satisfactory being that known as *GL*/50/3, which has a mean molecular size of 75,000 and contains 0·94 per cent sodium chloride. The optimum final concentration of this substance in the reacting system was found to be 1·0–1·5 per cent. Evaluation of the various fractions was based on two points: (1) the results obtained with a dextran-diluted univalent antiserum were required to agree exactly with those obtained by the same antiserum diluted with 20 per cent bovine albumin over a series of a thousand group tests; (2) the average quality of the agglutinates was required to be no poorer than that obtained with the albumin-containing system. The fraction *GL*/50/3 satisfied these criteria completely.

A serious disadvantage of this substance is its lack of latitude as regards optimum concentration. It was found necessary to titrate the dextran against the chosen antiserum using OR_1R_2 and *Orr* erythrocytes as indicators, a concentration giving the strongest agglutinations of positive cells together with absence of rouleaux formation of the negative cells being thus arrived at. This difficulty has up to now precluded the routine use of this substance as a suspension medium for standard cells in the detection of anti-*Rh* antibodies, but further work is proceeding along these lines.

Since this report was prepared, a communication by Grubb[3] has come to hand demonstrating a similar effect.

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A Fungus in *Ectocarpus granulosus* C. Agardh near Plymouth

During April and May 1949, *Ectocarpus granulosus* C. Agardh growing at mean low-water spring tide at Saltstone, which is about 1½ miles up the River Sal, from Salcombe, was heavily infected with a parasitic fungus. The Saltstone habitat is a purely marine one and is sheltered in the river estuary. The *Ectocarpus* grows attached to small stones and to other algæ in the *Vaucheria*-community. By July most of the *Ectocarpus* plants had disappeared from the locality.

The fungus is identical with *Eurychasma Dicksonii* (Wright) Magnus, a member of the Saprolegniales, which was first described in 1879 by Prof. E. P. Wright[1] from Ireland and later in 1887 by John Rattray[2] from Scotland. No records seem to have been made of this parasite in England. According to Sparrow[3] the fungus has a wide distribution on the Atlantic coasts of Europe. It infects other species of *Ectocarpus* as well as certain other members of the Phæophyceæ.

Thallus of *Ectocarpus granulosus* C. Ag., infected with *Eurychasma Dicksonii* (Wright) Magnus. (The arrow shows a discharged sporangium of the fungus)

Observations made on living plants show the size of the mature sporangium of the fungus to be about 70 μ × 90 μ (slightly larger than given by Sparrow). Each sporangium opens by one, two or rarely three short discharge tubes. Zoospores either emerge directly from the sporangium and swarm with two unequal flagella which are subapically disposed, or encyst inside the sporangium. Zoospores have been studied both while alive and after fixing with osmic acid and staining with 0·5 per cent Aniline Blue. They are hyaline, more or less rounded or slightly pyriform; each zoospore measures 3 μ × 4 μ. The longer flagellum is about four times the diameter of the zoospore itself, and the shorter, two to three times. The stages through which the protoplasm of the fungus passes, inside the host cell, agree well with the original description of the species.

Examination of several algæ in the same locality indicates the presence of other parasitic fungi. Marine fungi have so far received but little attention in England, and the part they play in causing the death of animals and plants must not be overlooked.

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Changes in the Response of Silkworm Eggs to Rotational Force during Cleavage

The eggs of the silkworm (*Bombyx mori*) have been used in several cases for studying the biological effects of rotational force (Kawaguchi[1], Tirelli[2]). But an interesting change in the response of silkworm eggs to centrifuging which occurs during the early cleavage stages escaped the notice of the authors. The change can be observed both morphologically in the process of pigment formation and physiologically in the rate of oxygen consumption of the eggs. Experiments which revealed the change were carried out in the Department of General Zoology, University of Budapest, in 1946 with eggs of the race Moretiana. The eggs were subjected for one hour to a centrifugal force of about 3,000 *g*, which caused a visible stratification of their contents. The treatment was applied either in (1) an 'early' stage, centrifuging starting two to three hours after the eggs were laid; or (2) a 'late' stage, treatment commencing fourteen to sixteen hours after oviposition. The temperature was approximately 26° C. throughout the experiments.

Eggs subjected to the treatment in the 'early' stage did not develop pigment at all, remaining bright yellow indefinitely, as at oviposition. In the eggs centrifuged in the 'late' stage, this suppression of pigment formation did not occur; they darkened simultaneously with the controls. The pigmentation in such 'late' centrifuged eggs is somewhat irregular. The pigment granules are not distributed evenly over the whole surface but are concentrated into patches. But neither their colour nor the time of their appearance differs in any way from the normal.

As regards oxygen consumption, there was a similar difference between eggs subjected to centrifuging in early and late stages respectively. In general, the oxygen consumption early after treatment was about 60–70 per cent of the normal; after late treatment it was about 80–90 per cent. As all experiments yielded practically identical results, only

Experiment	Control	Early treatment	Late treatment
8/6	19·5	13·9	17·2
8/9	20·7	12·2	18·1
8/8	25·8	18·0	20·4

a few typical examples are given here (oxygen consumption in cm.³ per hour per 500 eggs at 26° C.).

The results agree with those of Bodine and Boell[3], who ultracentrifuged the eggs of the grasshopper *Melanoplus*. Depression of respiration after ultracentrifuging has also been observed in the eggs of *Ascaris* (Huff and Boell[4]) and in liver cells of the frog (Chantrenne[5]). An explanation of these phenomena was given by the latter author, who finds that the cyanide-sensitive respiratory enzyme cytochrome-oxidase of the liver cells is associated with sedimentable granules of the cytoplasm; thus centrifuging separates the enzyme from its substrate, causing a marked decrease in the respiration (notably the cyanide-sensitive respiration, as shown by Bodine and Boell[3]). The general importance and widespread occurrence of such enzyme-containing, sedimentable cell constituents (Jeener and Brachet[6], Brachet[7]) indicates that the explanation of Chantrenne (fully supported by Brachet) holds good in all cases—including silkworm eggs—where decrease of respiration was observed after centrifuging. In the case of silkworm eggs, however, it may be added that the enzyme or enzymes associated with the sedimentable cell constituents must also be responsible for the pigment formation. (Knowing the close connexion between oxidations and pigment formation, one may even think of a double effect of the same enzyme system.)

There seem to be two possible explanations of the difference between the response of the eggs centrifuged in the early and late stages respectively: (1) either the viscosity of the cytoplasm is changed in relation to that of the sedimentable constituents containing enzymes of pigmentation and respiration; or (2) the position of these sedimentable elements is changed so that they migrate from less viscous regions of the cytoplasm to regions of higher viscosity. Tirelli[8] has shown that the viscosity of the cell sap of silkworm eggs increases continuously after oviposition, and Kawaguchi[1] explains some of his results by the assumption that three hours after oviposition the viscosity of the egg cytoplasm is higher than one to two hours after oviposition. These observations are in favour of explanation (1). However, there are several facts which indicate that explanation (2) may be equally true. It is known that the cleavage nuclei migrate from the interior of the egg cytoplasm to the cortical layer (*Keimhautblastem*), taking with them the yolk-free cytoplasmic islets which surround them. According to Bataillon and Tchou-Su[9], this migration takes place about twenty hours after oviposition at 20° C., but possibly much sooner at 26° C., at which our experiments were carried out. Furthermore, it is known from the experiments of Kawaguchi[1] that the cortical layer has a much higher viscosity than the inner cytoplasm, which is readily stratified by a rotational force of about 1,075 *g* applied for 10 min., whereas the cortical layer remains quite unaffected by this treatment. As it is probable that enzyme-containing sedimentable constituents of the cytoplasm would be found in the yolk-free islets surrounding the nuclei, the migration of these islets to regions of higher viscosity during the early stages of cleavage can explain the fact that these sedimentable constituents are less affected by the same rotational force in the 'late' than in the 'early' stage. It is hoped to check the validity of this explanation later by further—mainly histological—investigations.

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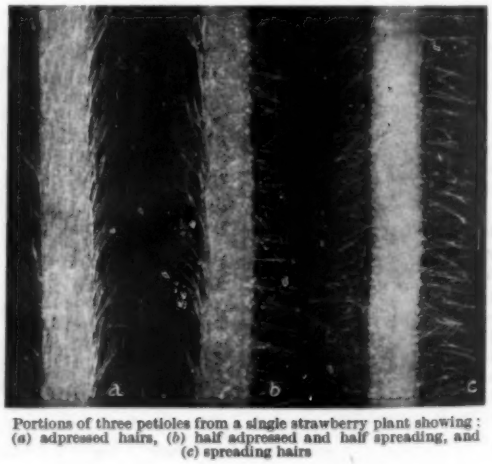
A Chimera in the Cultivated Strawberry

IN July 1949, Mr. J. E. Spickernell, provincial fruit specialist, East Midlands, discovered a variant in the *M*.40 clone of Royal Sovereign strawberry. In these plants the petiole hairs were adpressed upward, instead of spreading (that is, perpendicular to the petiole). In 757 plants of the same stock at this Research Station, 7·5 per cent were found to be of this variant form, and 1·1 per cent had both normal and variant crowns. In two plants some leaves with spreading hairs on one side of the petiole and adpressed ones on the other were found (see illustration), and in another, two consecutive runner plants on a single stolon had adpressed and spreading petiole hairs respectively.

This evidence suggests that the variant originally arose as a mutation, in the form of a sectorial or mericlinal chimera, from which normal vegetative propagation by runners has resulted in a population containing three types of plant, some having normal spreading petiole hairs, some adpressed and a few continuing as sectorial or mericlinal plants with both types of petiole hairs.

The variant plants resemble normal Royal Sovereign in every recognizable character except that of the petiole hair pose, and no significant



Portions of three petioles from a single strawberry plant showing: (*a*) adpressed hairs, (*b*) half adpressed and half spreading, and (*c*) spreading hairs

correlation was found between the number of variant plants and crop-weight of plots containing differing numbers of them. From the point of view of certification schemes, however, it is very desirable to eliminate the variant from stocks used for raising runners. Stocks will be maintained for investigation. Evidence so far suggests that the variant is confined to certain stocks sent from the Research Station in 1947 and 1948.

A note by Darrow[1] on a change in length of fruit-stalk, possibly due to mutation, is the only previous report of mutation in the strawberry that has come to my notice.

I wish to thank Mr. Spickernell for first reporting the variant, and Mr. M. B. Crane, Miss D. Wilson and others for further information.

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Soil and Vegetation in British Somaliland

The welcome publication of the first volume of Major Glover's work[1] directs attention to certain points regarding the soil and pastures in British Somaliland, which have been investigated for some years past, though little has been published. Opinion is divided on the extent and importance of the soil erosion, and the whole problem has recently been reviewed in detail by Brigadier (now Sir) Gerald Fisher[2], lately military governor.

Two factors, however, seem to have been generally overlooked.

First, the geological aspect. Probably in Upper Eocene times rift faulting in the Gulf of Aden trend (east-north-east) gave rise to the great northern Somaliland scarp, which now rises to heights of some 1,500–2,400 metres, and forms the backbone of the Somaliland Protectorate. Since then, for a matter of perhaps forty million years, all but a slight coastal strip has been continuously above the sea, and at roughly the same altitude as now. In Pleistocene times the country was strongly affected by the East African Pluvial periods, when great erosion took place, and later deposition of thick beds of red alluvium in many of the valleys.

The state of the countryside at the present day is fundamentally a legacy from the Pleistocene period. Lack or sparseness of soil-cover over much of the highlands may be ascribed to the intense Pleistocene denudation, and not to present-day erosion. It may even be that soil and vegetation in the highlands have been for the past five thousand years or more, and still are, slowly recovering under difficult conditions rather than deteriorating.

Secondly, an interesting phenomenon, which seems hitherto largely to have escaped notice, appears from a study of many air photographs of the country. A number of these, covering large areas of semi-desert plains of the Sawl Haud in the east of the Protectorate, and parts of the Haud in the south, show rhythmic patterns of the vegetation, which is concentrated in the form of tiers of arcs of mixed trees, shrubs, plants and grasses. These photograph black against a light background of bare desert. The patterns proved very difficult to recognize in the field, so that air photographs are essential for their study.

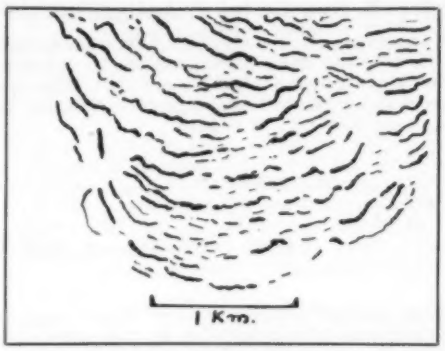


Diagram traced from air photo showing vegetation arcs at Gudubyero, Sawl Haud, British Somaliland, lat. 9° 44′ N., long. 48° 41′ E.

The vegetation arcs (see diagram) appear to be formed by the relatively rare rain storms, the water from which flows over this country of very low relief as a sheet, and not in incised water channels. It seems that accumulated organic debris, including seeds and also animal excreta (which is found in surprising abundance), are thus partially floated and carried along until for some reason not yet clear the load is deposited rhythmically in convex strand lines. Some of the seeds germinate and a vegetation arc is formed. This process appears to be repeated intermittently, and the arcs become firmly established features, practically all the vegetation of the semi-desert being concentrated in them. They include *Acacia* trees probably half a century old. The intervening ground, three or four times the width of the vegetation arcs, is kept almost completely bare.

As regards the scale, a single rhythm of vegetation arc and intervening desert averages about 160 metres, but may range from 70 m. to nearly 300 m.; the length of an individual arc is very variable, and may reach 2 km. or more.

The vegetation arcs are of practical value to the map-maker since they are invariably oriented with their convex sides directly up the slight slope, for which a preliminary value of *c.* 1 in 400 has been obtained. In fact, in some places they seem to form a rough approximation to naturally marked 'contours', with a vertical interval of the order of half a metre.

I suggest that this remarkable type of country, covered by tiers of these stable vegetation arcs, cannot at the present time be suffering appreciable soil erosion. Yet such country has been claimed as showing "severe erosion"; and Jacks and Whyte[3] have published an air photograph of it with the erroneous title "Wind erosion".

It is hoped to publish elsewhere a more detailed account of these and other vegetation patterns in the semi-deserts of Somaliland that are shown by the air photographs.

W. A. Macfadyen

Hope's Grove,
Tenterden, Kent.
June 23.

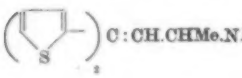
[1] Glover, P. E., "A Provisional Check List of British and Italian Somaliland Trees, Shrubs and Herbs" (London: Crown Agents for the Colonies, 1947. £4).

[2] "The Pastures of British Somaliland" (Aden: Cowasjee Dinshaw Press, 1947).

[3] Jacks, G. V., and Whyte, R. O., "The Rape of the Earth: a World Survey of Soil Erosion" (London, 5th Imp., 1947); see Fig. 14.

A New Series of Analgesics

A SERIES of potent analgesics, as active as morphine in the rat, has been discovered in the 3-tertiary-amino-1 : 1-(2′-thienyl)-but-1-enes (I). The analgesic toxicity ratios are not greatly different from that of amidone (II ; R = Me).



I

$CPh_2(COEt).CH_2.CHMe.NR_2$

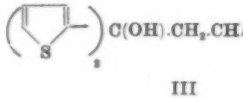
II

It is interesting that, as with other analgesics, the analgesia is accompanied by temperature and respiratory depression and by sedation in many laboratory animals, that an excitatory phase is manifest, particularly in the cat, and that high doses cause spasticity of the muscles and 'Straub tail' in rodents. The analgesic dose in dogs of compounds *a*, *b* and *d* is 5–10 mgm./kgm., as compared with 1–2 mgm./kgm. for amidone ; but the effect has not been accompanied by the gastro-intestinal disturbances which are common with amidone or morphine. The compounds also exhibit considerable antihistamine, spasmolytic and local anæsthetic activity.

Compound	Formula	Hydrochloride (m.p.)	Analgesic activity (P.95 limits)
a	I ; R=Me	169–170°	1·0 (0·87–1·2)
b	I ; R=Et	152–153	1·0 (0·83–1·1)
c	I ; NR_2=N<[CH_2]$_5$>CH_2	167–169	0·7 (0·58–0·84)
d	I ; NR_2=N<[CH_2]$_4$>CH_2	188–189	1·1 (0·97–1·3)
e	I ; NR_2=N<[CH_2]$_4$>O	181–182	0·3 (0·23–0·37)
Morphine	—	—	1·0 —

A limited analogy may be drawn between this and the amidone series, in so far as compounds of either series which lack the methyl side-chain are considerably less active. On the other hand, the morpholino group, which in the amidone structure (II ; NR_2 = N<[CH_2]$_4$>O) promotes the highest activity in the rat[1], has an unfavourable effect in this series (compound *e*) ; however, this divergence may not be so marked in other animals.

It has recently been stated[2] that amidone falls into line with other synthetic analgesics in that its spatial atomic arrangement bears a close relationship to that of morphine ; but it is difficult to discern any such structural similarity between the compounds (I) and morphine.



III

The amino-butenes (I) were obtained by the dehydration of the corresponding amino-carbinols (III ; R^1 = Me), which were prepared by the action of 2-thienyl-lithium on the appropriate ethyl β-aminobutyrate. The amino-carbinols themselves are potent spasmolytics ; for example, the *in vitro* and *in vivo* activity of 3-N-piperidino-1 : 1-(2′-thienyl)-propan-1-ol (III ; R^1 = H ; NR_2 = N < [CH_2]$_4$ > CH_2 ; m.p. 70–72°, hydrochloride, m.p. 198° (decomp.)) is favourable in relation to synthetic spasmolytics now in clinical use. The amino-carbinols are also potent local anæsthetics.

This work forms part of a programme for the synthesis and pharmacological investigation of amino-alkyl tertiary carbinols and derived products, part of which is already described[3].

D. W. ADAMSON
A. F. GREEN

Wellcome Research Laboratories,
Beckenham, Kent.
Aug. 30.

[1] Attenburrow, J., Elks, J., Hems, B. A., and Speyer, K. N., *J. Chem. Soc.*, 510 (1949).
[2] Bergel, F., and Morrison, A. L., *Quart. Rev., Chem. Soc.*, **3**, 381 (1948).
[3] Adamson, D. W., *J. Chem. Soc.*, S 144 (1949).

Exchange in Cobalt Chelate Compounds

RECENT advances in nutrition chemistry have indicated the importance of co-ordination compounds in the uptake of cobalt by animals. With the advent of supplies of cobalt-60, obtained through the courtesy of the U.S.A.E.C., we in Adelaide have become interested in the possible exchange reactions between cobaltous ions and cobalt chelate compounds. Flagg[1], McCallum and Hoshowsky[2] have reported no evidence for exchanges of this type with a number of cobaltammines. However, Pauling[3] has pointed out that for co-ordination compounds the bond between the metal and its co-ordinated groups will be predominantly ionic if the compound exhibits a high paramagnetism, for example, 3–5 μ. It therefore appeared to us that exchange by an ionic mechanism should occur between metal ions and those co-ordination compounds of the metal which show high values of μ. Evidence for this theory has been presented by Johnson and Hall[4] in their work on the exchange of nickel derivatives with Ni^{++} ions.

The experimental procedure adopted in our work has been to mix solutions of chelate and cobalt sulphate, equimolal with respect to cobalt, and then to separate the two after various time intervals, by an extraction procedure. The tracer, cobalt-60, is always placed in the cobalt sulphate, and evidence for exchange is based on the appearance of activity in the chelate extract, activities being measured by a solution type, jacketed counter, holding 10 ml. Three extraction methods are employed : (1) water-soluble chelates are mixed with aqueous cobalt sulphate and the Co^{++} extracted as the thiocyanate complex with ether ; (2) pyridine-soluble chelates are mixed with aqueous cobalt sulphate and the chelate extracted with chloroform ; (3) insoluble chelates are shaken with aqueous cobalt sulphate, filtered off, dissolved in hydrochloric acid and counted. The following results are of interest (Table 1).

Table 1

Cobalt compound	Extraction	Temp.	μ [5]	Remarks
Disalicylaldehyde	(2)	20°	4·5	Complete exchange within 50 sec.
Guaiacol	(3)	20°	4·5	Steady exchange becoming complete in just over 2½ hr.
Triethylenediamine chloride	(1)	20°	0	No exchange over 24 hr.
Disalicylaldoxime	(2)	20°	2·6	Slight exchange (see later)
	(2)	45°		

Exchange has thus been found to occur where expected, for the salicylaldehyde and guaiacol derivatives, under the experimental conditions. The fact that the salicylaldehyde complex gives complete exchange almost immediately whereas with guaiacol the exchange is at a steady rate to eventual equilibrium, in spite of their similar susceptibilities, may be due in part to the experimental method. Exchange between a solid and a liquid would obviously be expected to be slower than exchange occurring when both substances are in solution. If the guaiacol complex were soluble, then immediate exchange might result (neglecting structural factors). For the ethylenediamine complex, diamagnetism suggests strong covalent bonding, and no exchange was observed, as had been predicted. In the case of the salicylaldoxime complex, a rather peculiar result has been obtained (Table 2).

Table 2. Cobalt salicylaldoxime : 5 ml. pyridine solution, 5 ml. cobalt sulphate solution (water), each, 1 mgm. cobalt/ml.

Temp.	Time (min.)	Water activity (made to 25 ml., 10 ml. sample)	Chloroform activity (made to 25 ml., 10 ml. sample)
20°	3	228·7 ± 2·0	20·0 ± 0·98
	6	223·0 ± 2·0	19·9 ± 0·93
	60	232·0 ± 2·0	18·3 ± 0·92
45°	10	220·7 ± 2·0	29·8 ± 1·0
	90	224·9 ± 2·0	32·7 ± 1·1
	240	220·5 ± 2·0	35·4 ± 1·1

At 20° the activity in the chelate layer remains constant within the probable error of counting over 1 hr., and at 45° seems to increase slightly over 4 hr. A 'blank' extraction with cobalt sulphate alone shows that chloroform extracts less than 0·01 per cent cobalt under these conditions ; hence the activity cannot be due to retention of cobalt in the chloroform extract. Exchange had not been expected here, because of the low paramagnetism of the complex. The corresponding nickel compound[4] has, however, been shown to exhibit exchange in methyl 'Cellosolve'. Mellor and Willis[6] have shown that the solid, diamagnetic, nickel complex forms an octahedral complex in pyridine solution, giving the solution a high paramagnetism, and a similar complex formation in the case of the cobalt derivative may explain the observed results. Formation of a dipyridine salicylaldoxime complex may occur in solution, giving a mixture of planar salicylaldoxime and octahedral dipyridine complexes, one of which may be present in small amount. If this compound in small amount can undergo immediate exchange, then the appearance of the constant activity is accounted for, assuming the amount of that compound remains constant, over the time interval of the experiment. At 45°, more of the 'exchangeable' compound has probably formed ; hence the slight increase in the amount of activity found in the chelate.

These investigations are being extended and a fuller account of the work will be published elsewhere.

B. West

Johnson Chemical Laboratories,
University of Adelaide.
Aug. 16.

[1] Flagg, J. F., *J. Amer. Chem. Soc.*, **63**, 557 (1941).
[2] McCallum, K. J., and Hoshowsky, S. A., *J. Chem. Phys.*, **16**, 254 (1948).
[3] Pauling, L., "Nature of the Chemical Bond", 115 (2nd edit., Cornell University Press, 1948).
[4] Johnson, J. E., and Hall, N. F., *J. Amer. Chem. Soc.*, **10**, 2344 (1948).
[5] Values taken from Mellor, D. P., and Craig, D. P., *J. Proc. Roy. Soc. N.S.W.*, **74**, 495 (1940).
[6] Willis, J. B., and Mellor, D. P., *J. Amer. Chem. Soc.*, **69**, 1237 (1947).

X-Ray Irradiation of Polystyrene, Polythene and Paraffin Wax

It seemed desirable to compare the effects of X-ray irradiation of cellulose acetate already reported by N. N. Winogradoff[1] with the effects produced in other plastics.

Samples of polystyrene, polythene and paraffin wax measuring roughly 4 cm. × 5 cm. × 0·2 cm. were, in turn, laid over a 1·0-cm. circular aperture in a lead screen 0·3 cm. thick and irradiated through this aperture by radiation emerging from a 0·001-in. aluminium window of a 'Raymax' copper-target X-ray tube operated at 50 kVp., 30 m.amp. for periods up to 60 hr.

No evidence of brittleness of the irradiated patches was found. The X-ray diffraction patterns before and after prolonged irradiation showed no definite change in any of the structures.

As already reported by C. W. Wilson[2], on introducing the above samples into the X-ray beam, all three showed a definite bluish-white luminescence. After exposure of the order of 60 hr., the polystyrene and polythene samples showed a marked yellow-brown discoloration of the irradiated patch, and although no discoloration was observed in the paraffin wax sample, the irradiated patch was found to be more opaque than the rest of the translucent sample.

On removing the lead screen and irradiating the whole sample, the discoloured patch on the polystyrene sample glowed several times more brilliantly than the regions previously shielded from the X-rays ; this glow persisted for a few seconds after removing the samples from the X-ray beam. Similar but much weaker effects were observed with polythene, but the persistence of the afterglow was of very short duration, if present at all.

Exposure of the samples to ultra-violet radiation from an 'Osira' black-bulb mercury-vapour lamp showed a very marked luminescence of the X-ray irradiated patches in the polythene and paraffin samples ; but the patch in the polystyrene sample appeared to be almost black in comparison with the slight luminescence of the unexposed parts. On placing the polystyrene sample between the ultra-violet lamp and an anthracene screen, the slightly discoloured patch threw a very dark shadow on the screen, showing that prolonged exposure to X-rays produced strong absorption of ultra-violet radiation in polystyrene. This effect may have useful applications. Some ultra-violet fatigue effects were also observed.

This induced phosphorescence, discoloration, and the increased electrical conductivity of polystyrene on exposure to X-rays reported by F. T. Farmer[3], seem to show that the X-rays not only raise the electrons to the conduction band but also produce electron traps quite apart from any impurity centres which may have been present initially (see C. W. Wilson[2]). The ultra-violet absorption band indicates that the energy-levels of these induced electron traps are well below the conduction band.

I am indebted to the directors of Lansil, Ltd., for permission to publish this note.

N. N. Winogradoff

Research Laboratory,
Lansil, Ltd.,
Lancaster.
July 14.

[1] *Nature* [**165**, 72 (1950)].
[2] Wilson, C. W., *Nature*, **161**, 520 (1948).
[3] Farmer, F. T., *Nature*, **150**, 521 (1942) ; *Brit. J. Rad.*, **18**, 148 (1945).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, January 23

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Prof. Gordon Manley: "The Changeability of the British Climate".

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (in the Reynolds Hall, College of Technology, Manchester), at 5.30 p.m.—Symposium on "The Voluntary Social Services".*

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Prof. P. Grabar (Institut Pasteur): "Origin and Functions of Globulins and Antibodies".*

INSTITUTION OF THE RUBBER INDUSTRY, MANCHESTER AND DISTRICT SECTION (at the Engineers' Club, Albert Square, Manchester), at 6.15 p.m.—Mr. K. W. Hayes: "Some Aspects of the Stability of Compounded Latex".

INSTITUTION OF ELECTRICAL ENGINEERS (at the Great Western Hotel, Reading), at 7 p.m.—Dr. T. E. Allibone, F.R.S.: "Trends of Development in Atomic Energy".

Tuesday, January 24

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Mr. J. A. Purser: "Introducing a Psychological Approach to Management".

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5 p.m.—Dr. Madeline Kerr: "Culture Contact and Conflict in Jamaica".

ROYAL SOCIETY OF ARTS, DOMINIONS AND COLONIES SECTION (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Mr. E. Bruce Levy: "Grasslands in the Commonwealth".

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. C. A. B. Smith: "Fitness and Survival".*

PLASTICS INSTITUTE, LONDON AND DISTRICT SECTION (at the Waldorf Hotel, Aldwych, London, W.C.2), at 6.30 p.m.—Symposium on "Synthetic Finishes".

SOCIETY OF DYERS AND COLOURISTS, MANCHESTER SECTION (at the Textile Institute, 16 St. Mary's Parsonage, Manchester), at 7.15 p.m.—Mr. G. K. Mecklenburgh: "The Dyeing and Finishing of Nylon Textiles".

Wednesday, January 25

PHYSICAL SOCIETY, OPTICAL GROUP (at the Northampton Polytechnic, St. John Street, London, E.C.1), at 3 p.m.—Dr. W. D. Wright: "The Role of Convergence in Stereoscopic Acuity"; Mr. L. P. C. J. Dudley: "Auto-Stereoscopic Photography".

ROYAL SOCIETY OF MEDICINE, ENDOCRINOLOGY SECTION (at 1 Wimpole Street, London, W.1), at 5 p.m.—Dr. A. S. Parkes, F.R.S.: "Hormone Assays on Body Fluids" (Presidential Address).

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5.10 p.m.—Annual General Meeting; Sir Robert Watson-Watt, F.R.S.: "The Evolution of Meteorological Institutions in the United Kingdom".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. E. Orowan, F.R.S.: "The Mechanical Strength of Solids".* (Further Lectures on February 1 and 8.)

INSTITUTE OF WELDING (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Mr. W. K. B. Marshall: "The Welding of Light Alloys in Structural and Similar Applications".

SOCIETY OF CHEMICAL INDUSTRY, NUTRITION PANEL OF THE FOOD GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—Dr. W. F. J. Cuthbertson: "The Vitamins—Up-to-date Review".

ROYAL STATISTICAL SOCIETY, BIRMINGHAM GROUP of the INDUSTRIAL APPLICATIONS SECTION (in the Chamber of Commerce, 95 New Street, Birmingham), at 6.30 p.m.—Mr. W. A. Bennett: "Statistical Quality Control Applications".

ROYAL INSTITUTE OF CHEMISTRY, DUBLIN AND DISTRICT SECTION (in the Department of Chemistry, University College, Dublin), at 7.45 p.m.—Dr. E. C. Knight: "Chemical Activities of Micro-Organisms".

Thursday, January 26

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. G. R. de Beer, F.R.S.: "Embryos and Ancestors".*

SOCIETY OF ANTIQUARIES OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. D. A. E. Garrod: "Excavation in an Early Magdalenian Rock-Shelter at Angles-sur-l'Anglin in the Vienne".

ROYAL STATISTICAL SOCIETY, SHEFFIELD GROUP of the INDUSTRIAL APPLICATIONS SECTION (in Room B.1, The University, St. George's Square, Sheffield), at 6.30 p.m.—Miss J. Keen: "Statistics and the Craftsman".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion on "Genetical Factors in the Study of Anthropology". (Speakers: Dr. A. E. Mourant, Mr. N. A. Barnicot and Dr. H. Lehmann.)

Friday, January 27

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Geophysical Discussion on "Glaciology".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Prof. M. G. Kendall: "Factor Analysis as a Statistical Technique"; Mr. B. Babington Smith: "An Evaluation of Factorial Analysis from the Point of View of a Psychologist".

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Dr. T. W. F. Brown: "Some Factors in the Use of High Temperatures in Gas Turbines".

TELEVISION SOCIETY (at the C.E.A., 164 Shaftesbury Avenue, London, W.C.2), at 7 p.m.—Mr. R. C. Mildner: "High Frequency Cables in Television".

CHEMICAL SOCIETY, GLASGOW SECTION (at the Royal Technical College, Glasgow), at 7.15 p.m.—Prof. F. S. Spring: "Recent Advances in the Chemistry of the Steroids".

Saturday, January 28

NUTRITION SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 10.20 a.m.—"Commonwealth Contributions to the British Diet".

BRITISH PSYCHOLOGICAL SOCIETY, SCOTTISH BRANCH (in the George Combe Psychological Laboratory, The University, Edinburgh), at 2.30 p.m.—Symposium on "The Scottish Mental Survey, 1947" (Speakers: Sir Godfrey Thomson, Mr. James Maxwell and Mr. D. Kennedy-Fraser).

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. C. J. Hackett: "The Aborigines of Central Australia".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

HEAD OF THE ELECTRICITY SECTION, Defence Research Laboratories, Melbourne, and a SUPERINTENDING GEOPHYSICIST in the Bureau of Mineral Resources, Geology and Geophysics, Melbourne—The Australian Munitions Representative, Canberra House, 85–87 Jermyn Street, London, S.W.1 (January 26).

HEAD OF THE DEPARTMENT OF PHYSICS AND MATHEMATICS, and a HEAD OF THE DEPARTMENT OF CHEMISTRY—The Registrar, Birmingham Central Technical College, Suffolk Street, Birmingham 1 (January 28).

LECTURER IN PHYSICS at the Coventry Technical College—The Director of Education, Education Offices, Coventry (January 28).

PHYSICIST, and a CHEMIST, for work concerned with various aspects of the manufacture and properties of knitted products—The Secretary, Hosiery and Allied Trades Research Association, 4 First Avenue, Sherwood Rise, Nottingham (January 28).

CHEMIST or PHYSICIST (Rubber Technologist) for the organisation of rubber testing, laboratory and research on testing methods, a CHEMIST (Chemical Engineer) for research on unit processes applied to the preparation of plantation rubber, a CHEMIST (Biochemist) for research on the constituents and enzymology of latex, a CHEMIST (Analyst) for the organisation of analytical laboratory, a CHEMIST (Physical Chemist) for the study of rubber as a high polymer, a CHEMIST (Colloid Chemist) for research on the colloidal properties of latex, a BOTANIST (Plant Physiologist) for research on the physiology of latex formation in the growing plant, a MICRO-BIOLOGIST for the study of microbiology of soils under cultivation with *Hevea* with particular reference to the nitrogen cycle in tropical soils, an AGRICULTURAL ENGINEER or SOILS CHEMIST with research experience in problems of mechanical cultivation, and a STATISTICIAN for the design of experiments, research in statistical methods and their application, at the Rubber Research Institute, Kuala Lumpur, Malaya—The Secretary, London Advisory Committee for Rubber Research (Ceylon and Malaya), Imperial Institute, London, S.W.7.

CHIEF TECHNICAL ENGINEER (with honours degree) to take charge of an engineering section responsible for all the major calculations involved in the design and construction of factories for producing fissile material, a CHIEF POWER SERVICES ENGINEER to be responsible for the design and lay-out of all steam and electrical services for large factories, a DEPUTY CHIEF INSTRUMENT ENGINEER to be responsible for the provision and adaptation of instruments for the Division's factories, a PLANNING ENGINEER to undertake the construction planning of a large factory, and an ELECTRICAL ENGINEER to be responsible for electrical installation design work on large factories with grid intake—The Administrative Branch, Ministry of Supply, Division of Atomic Energy (Production), Risley, near Warrington, Lancs.

LECTURER IN PHYSIOLOGY—The Secretary, King's College of Household and Social Science, Campden Hill Road, London, W.8.

METALLURGIST (with degree in metallurgy or equivalent qualifications) for the application of research results to industrial practice—The Secretary, British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1.

METALLURGIST to take charge of Metallurgical Development Laboratories, and a DEVELOPMENT ENGINEER to assist in the operation of a prototype plant and to co-ordinate the results for major design purposes, at the Ministry of Supply Division of Atomic Energy (Production), at Springfields Factory, Preston—The Administrative Branch, Ministry of Supply, Division of Atomic Energy (Production), Risley, near Warrington, Lancs.

RESEARCH ASSISTANT for work relating to analysis and testing of coal and the products of its combustion, and a RESEARCH OFFICER (with B.Sc. or equivalent in mechanical or chemical engineering) for experimental work relating to industrial combustion equipment—The Assistant Secretary, British Coal Utilisation Research Association, Randalls Road, Leatherhead, Surrey.

RESEARCH OFFICER, Ebini Livestock Station, British Guiana, to undertake duties involving the planning and supervision of research and other projects at the Station for the purpose of ascertaining the most economic methods of developing the minerally deficient savannahs of the area—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1.